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Kim et al.

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(45) Date of Patent: Apr. 2, 2019

(54) WASHING MACHINE AND METHOD OF CONTROLLING THE SAME USING AN AC MOTOR

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(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

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Jan. 30, 2015 (KR) 10-2015-0015343

(51) **Int. Cl.**

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D06F 35/00	(2006.01)
D06F 33/02	(2006.01)

(52) **U.S. Cl.**
CPC ***D06F 37/304*** (2013.01); ***D06F 33/02*** (2013.01); ***D06F 35/005*** (2013.01); *D06F 2202/065* (2013.01); *D06F 2204/065* (2013.01); *D06F 2232/08* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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* cited by examiner

Primary Examiner — Rita P Adhlakha

(57) **ABSTRACT**

A washing machine includes an alternating current (AC) motor which generates torque, a clutch assembly which selectively transfers the torque to a rotating tub and a pulsator, a speed detector which detects a rotary speed of the clutch assembly, and a controller configured to repetitively perform operating and stopping the operating of the AC motor based on a predetermined target speed and the rotary speed of the clutch assembly in a spin-drying operation. The controller gradually increases the torque of the AC motor while operating the AC motor.

20 Claims, 30 Drawing Sheets

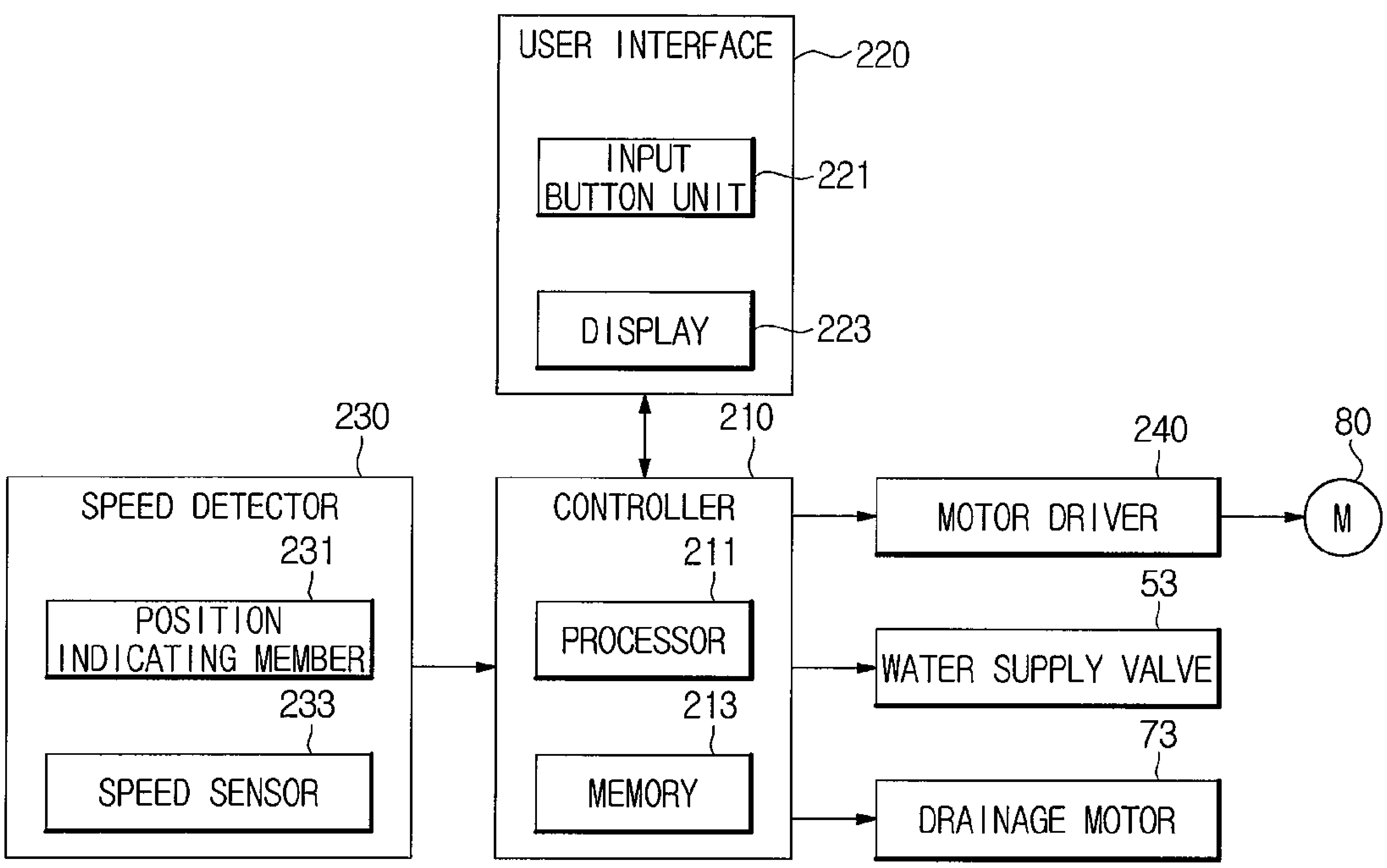


FIG. 1

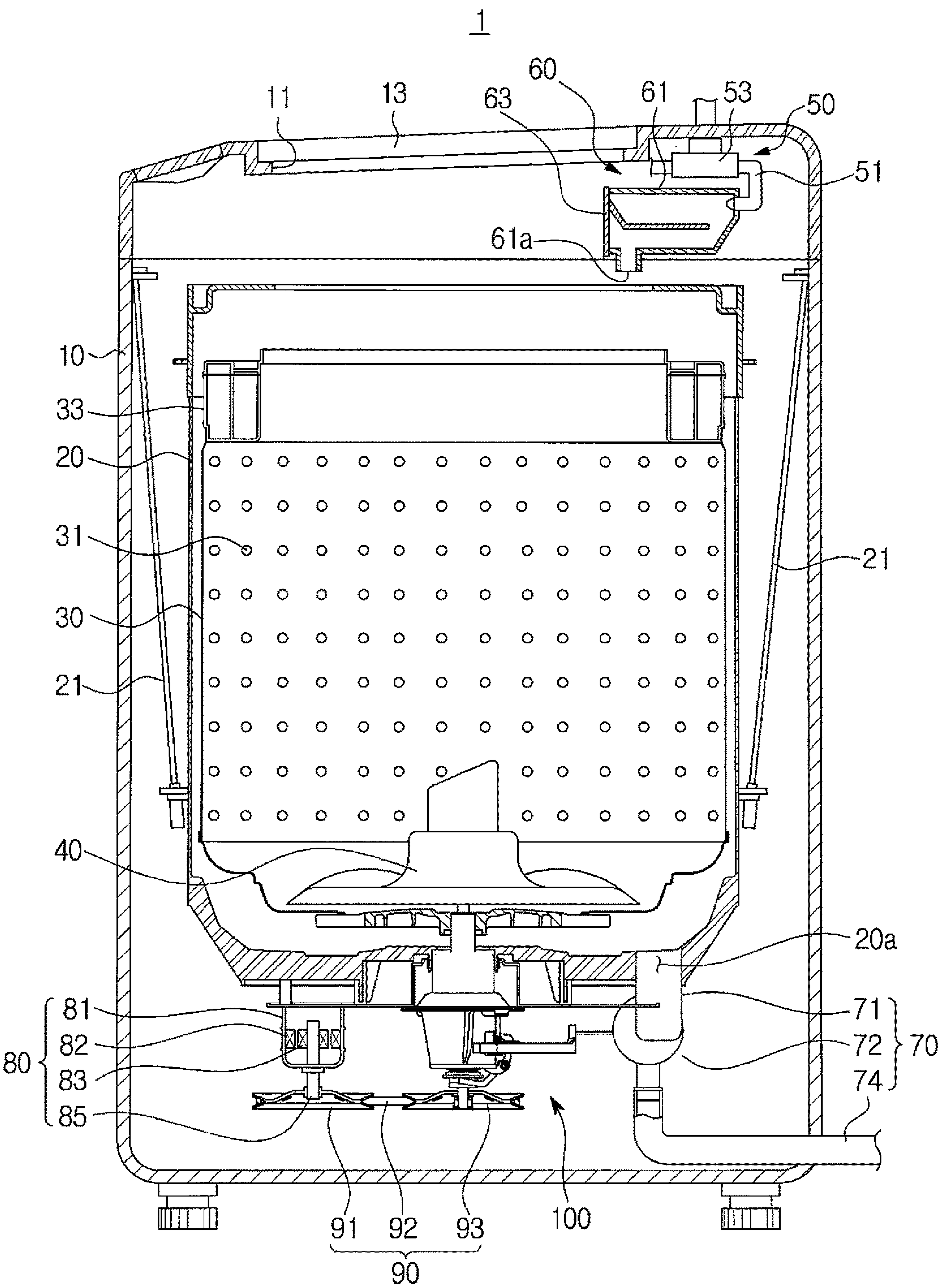

1
60
11
13
63
61
53
50
51
61a
10
33
20
31
21
30
21
40
20a
81
71
82
72
70
80
83
74
85
91
92
93
100
90

FIG.2

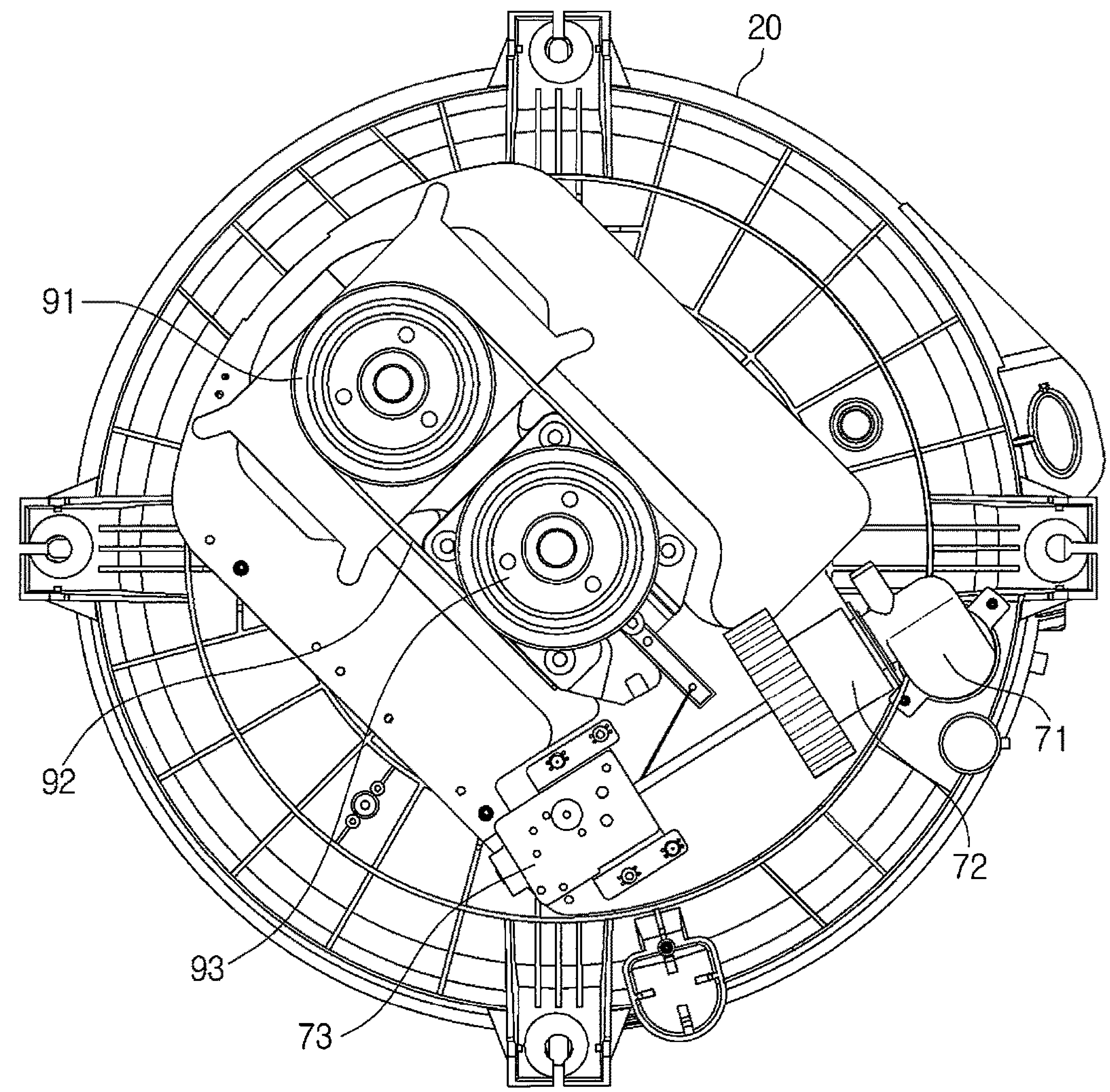


FIG.3

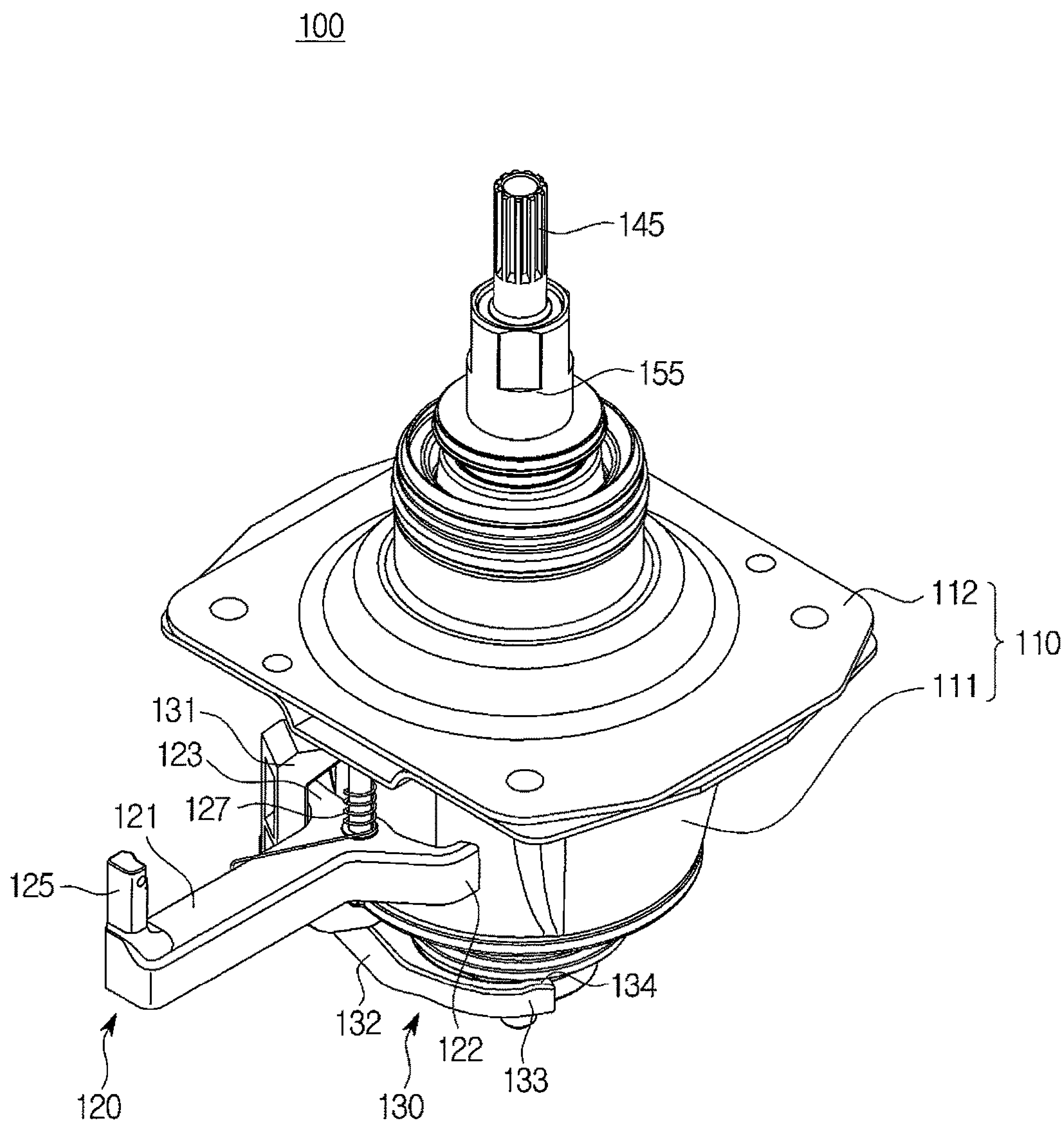

100
145
155
112
110
111
131
123
127
121
125
134
132
122
133
120
130

FIG.4

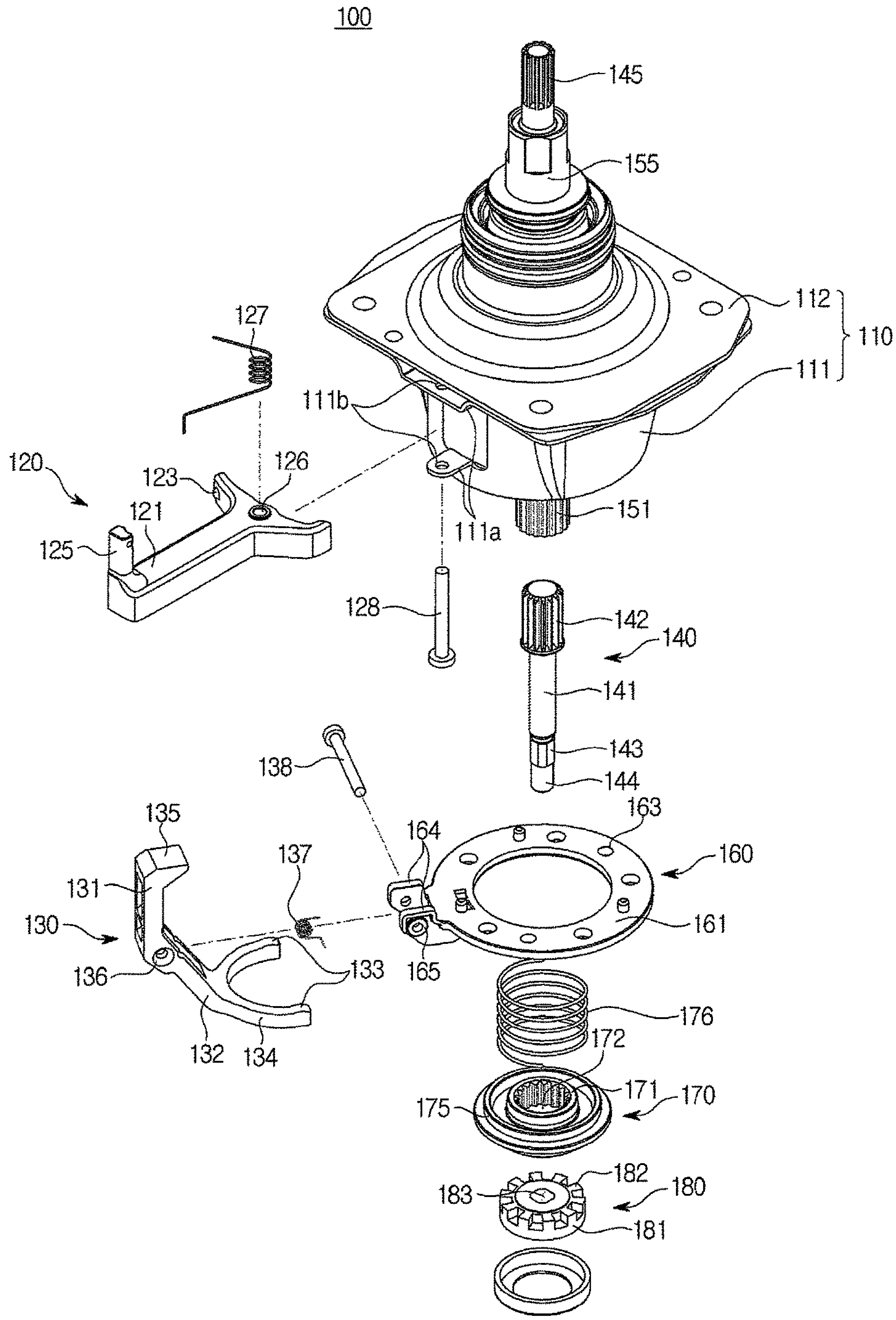

100
145
155
112
110
111
127
111b
120
123
126
121
125
151
111a
128
142
140
141
143
144
138
135
163
164
137
160
131
130
161
136
133
165
176
132
134
172
171
170
175
182
180
183
181

FIG.5

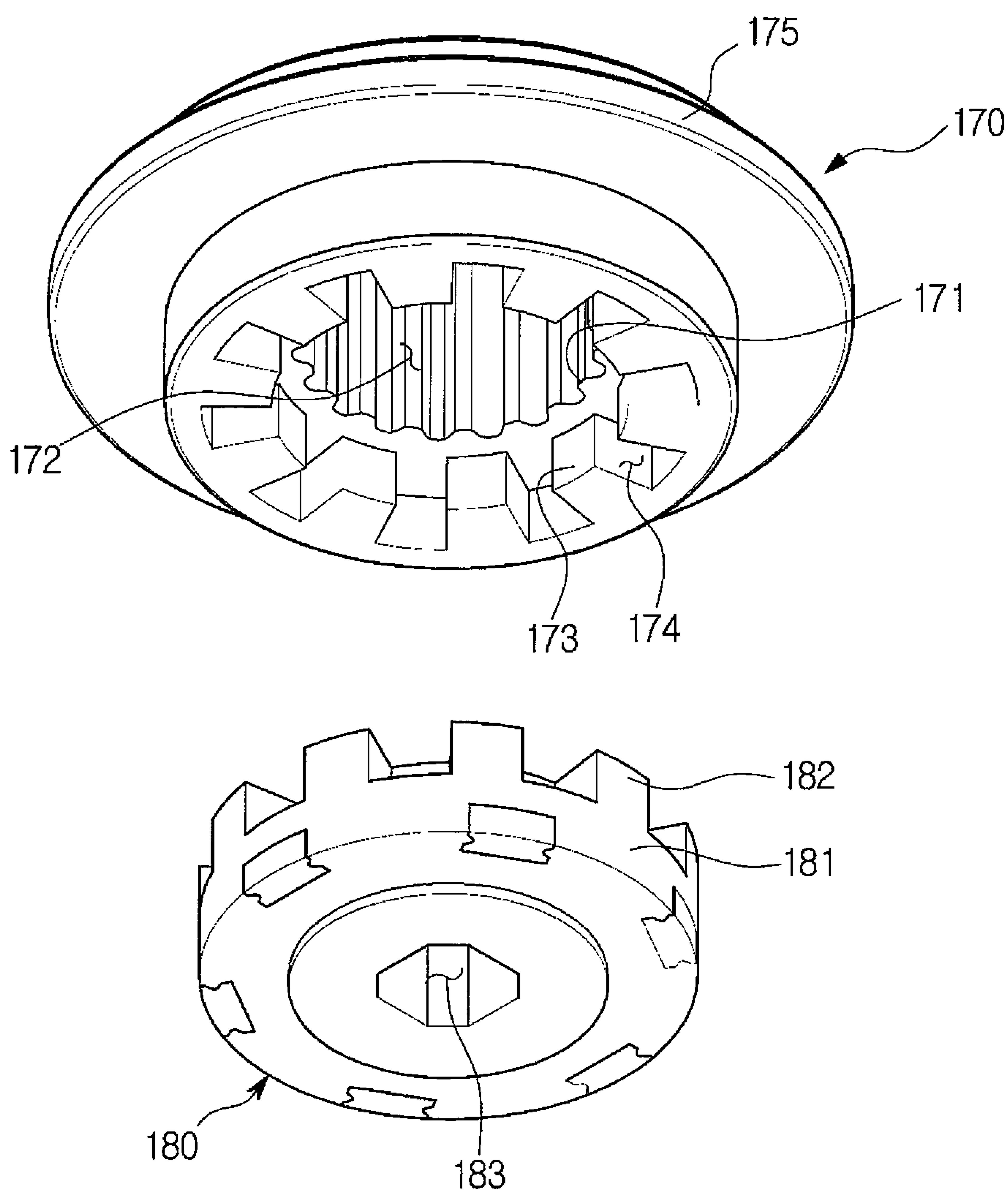


FIG.6

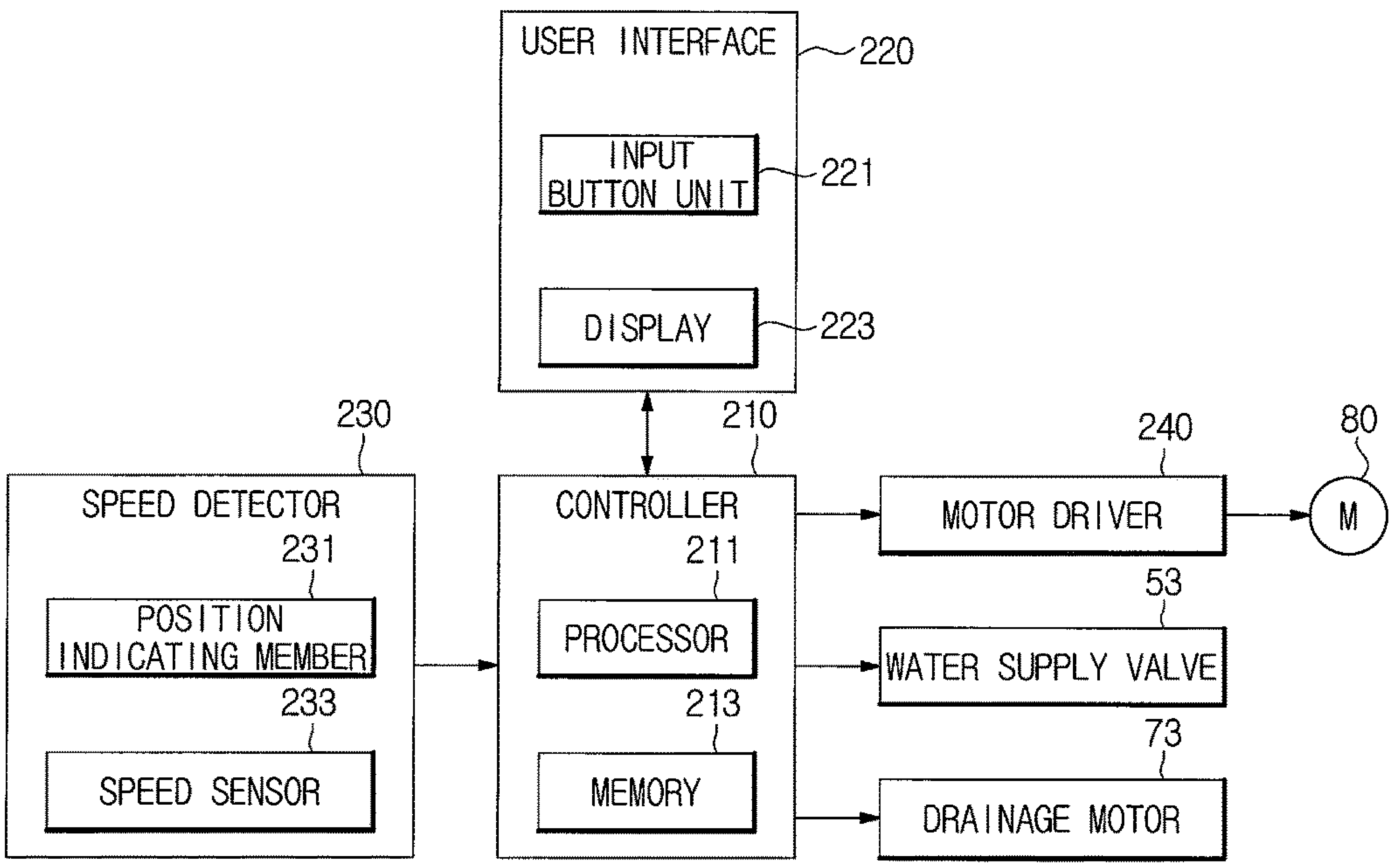

USER INTERFACE
220
INPUT BUTTON UNIT
221
DISPLAY
223
230
210
240
80
SPEED DETECTOR
231
POSITION INDICATING MEMBER
233
SPEED SENSOR
CONTROLLER
211
PROCESSOR
213
MEMORY
MOTOR DRIVER
M
53
WATER SUPPLY VALVE
73
DRAINAGE MOTOR

FIG.7A

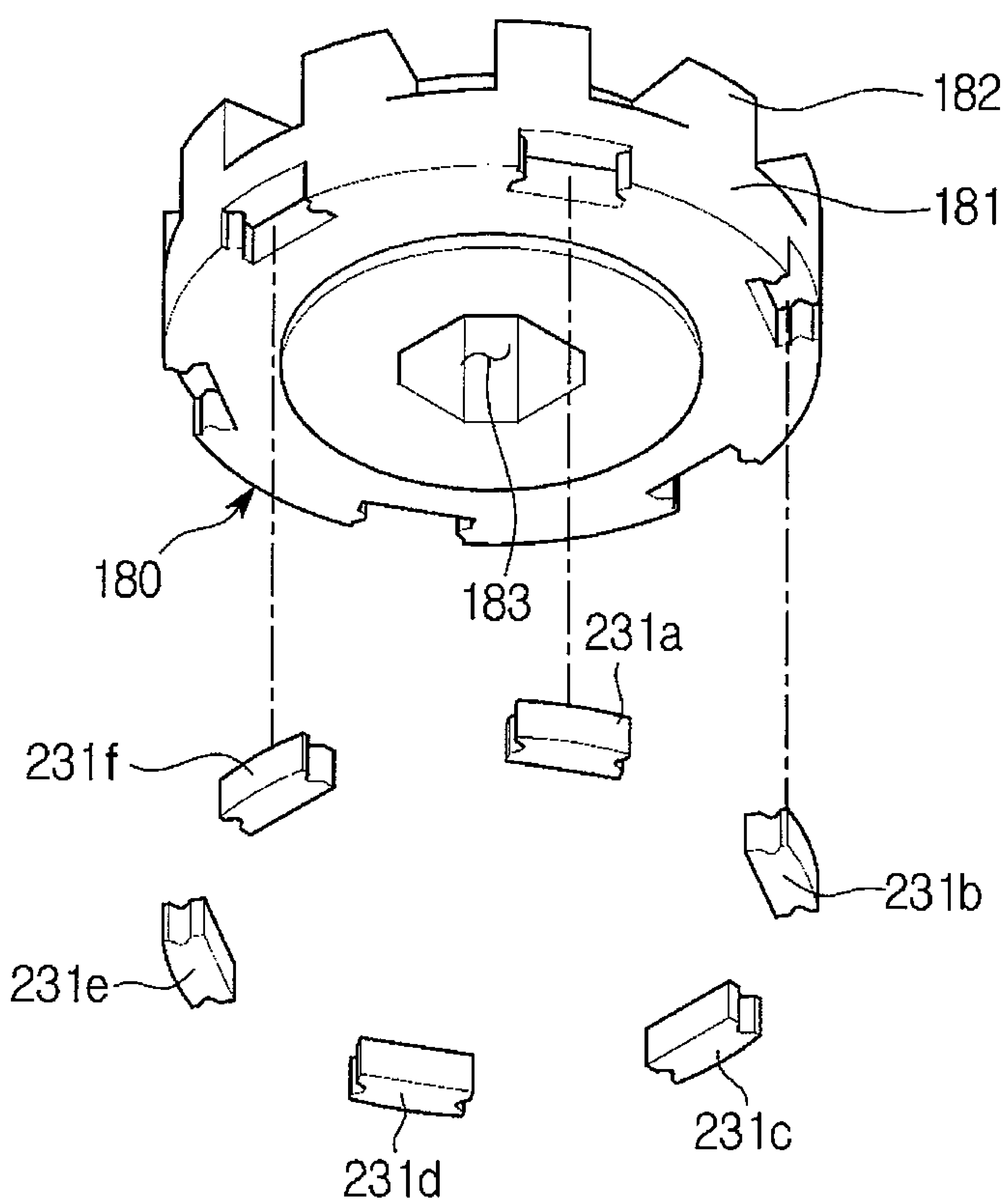


FIG.7B

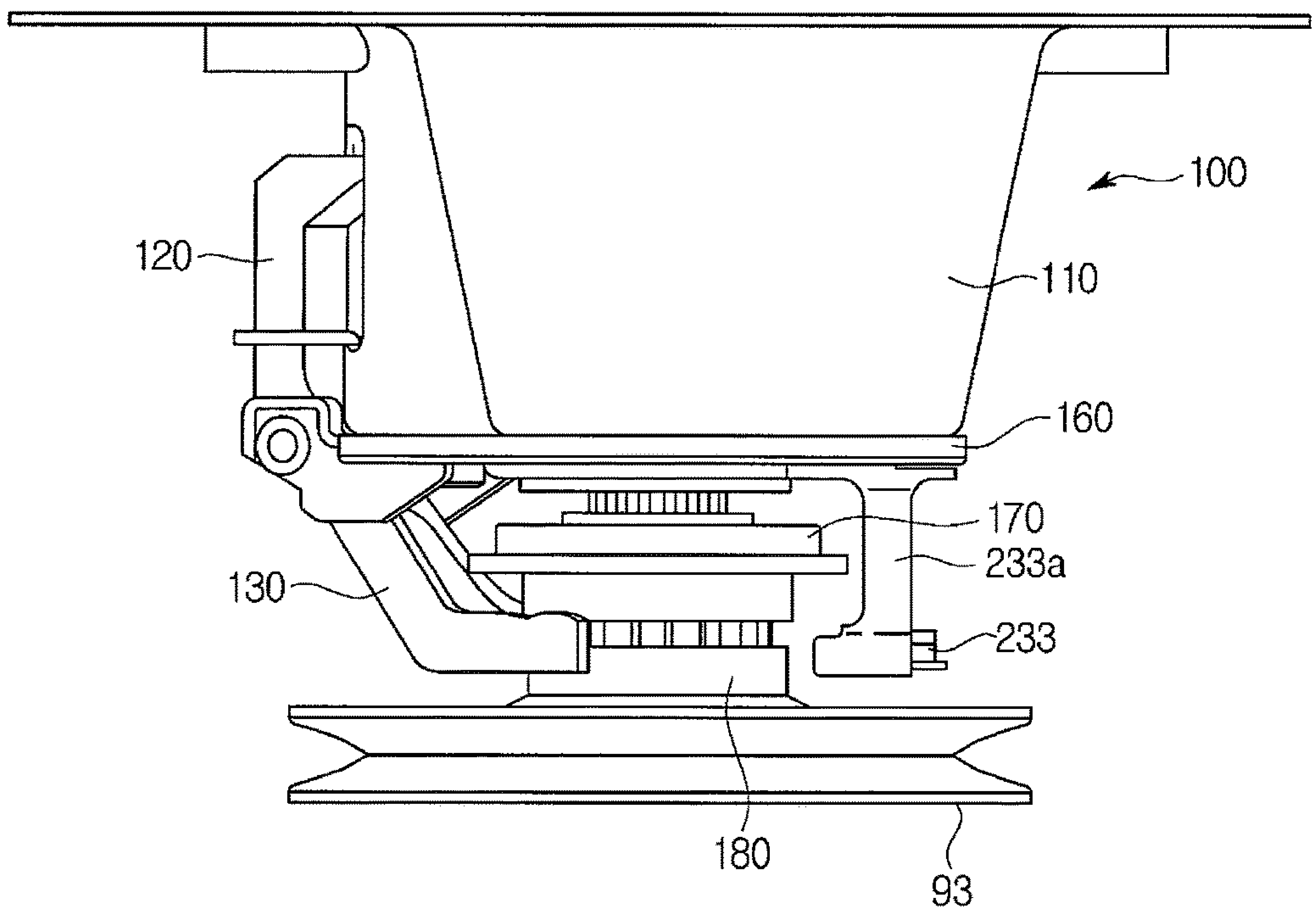
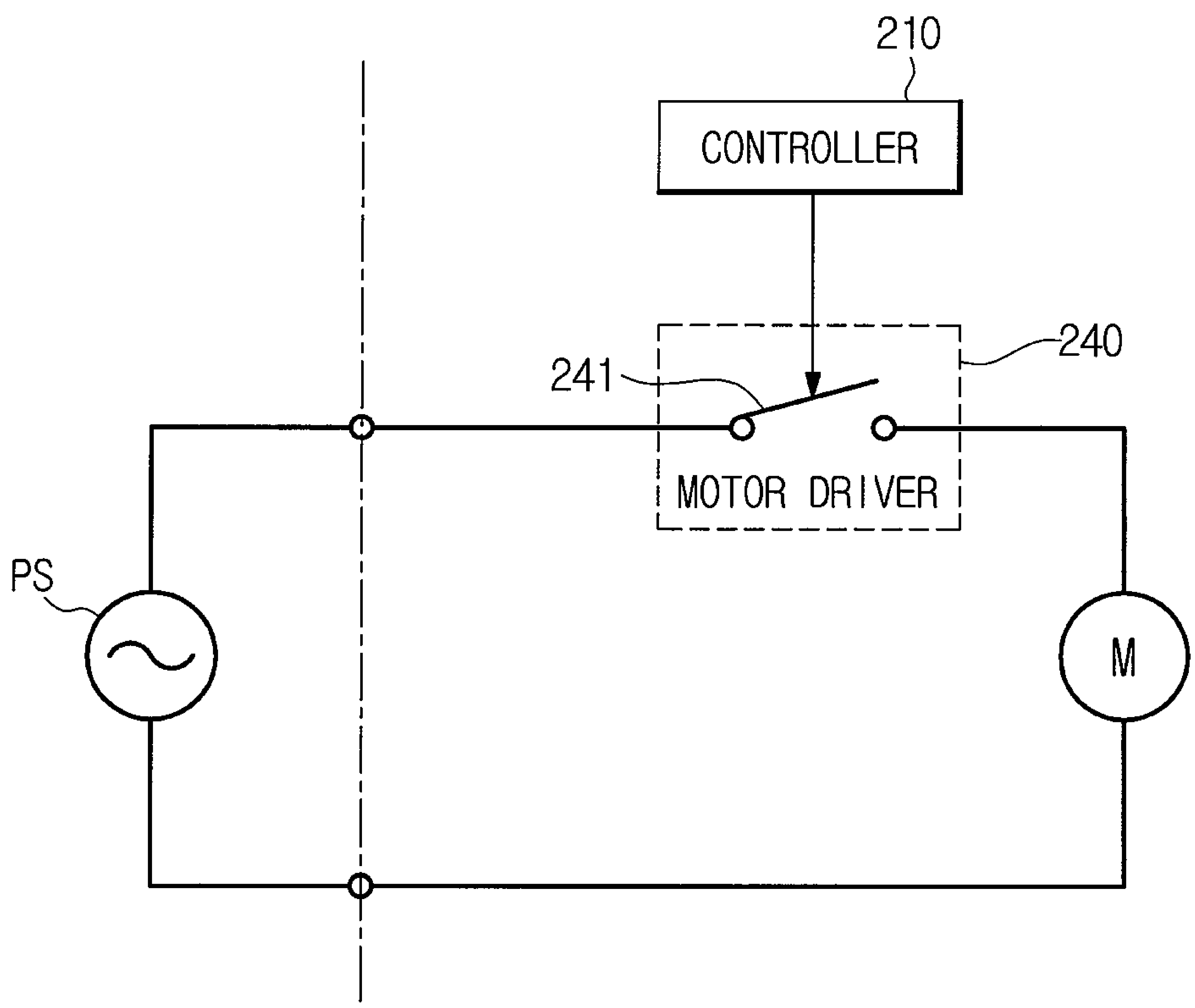


FIG.8



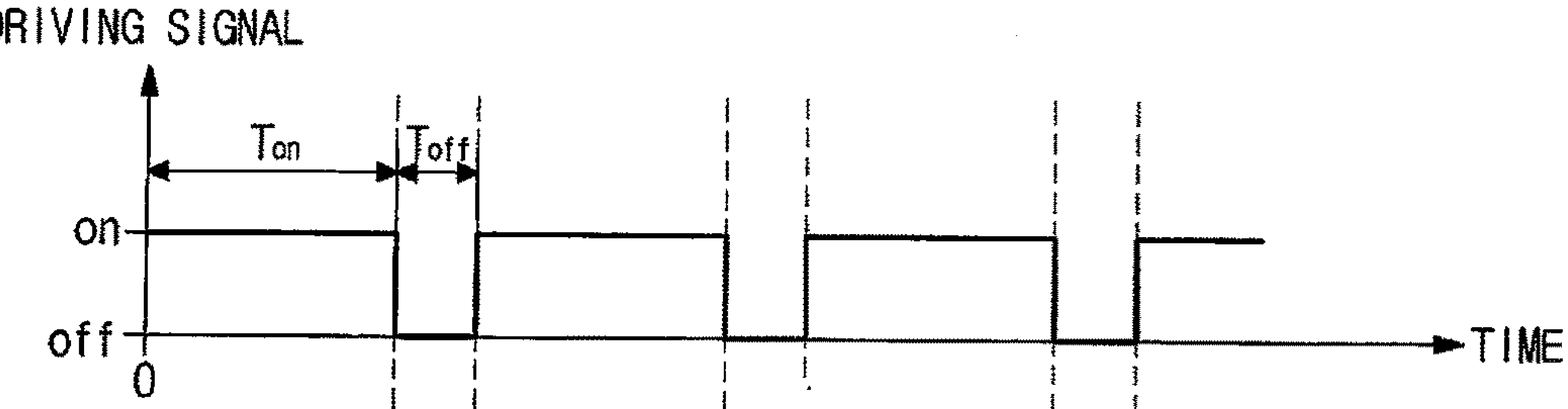


FIG.9A

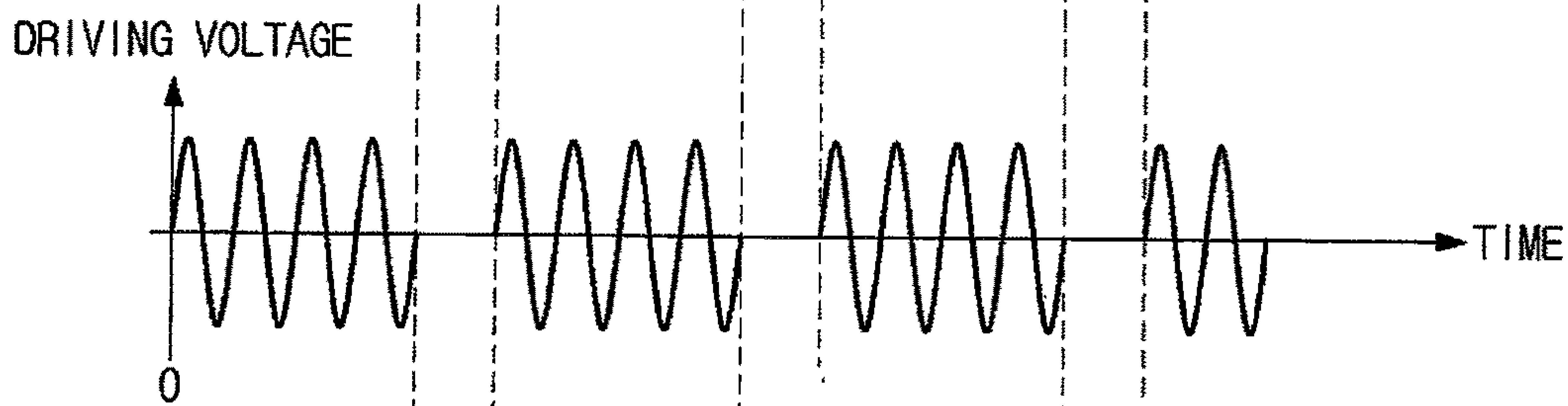


FIG.9B

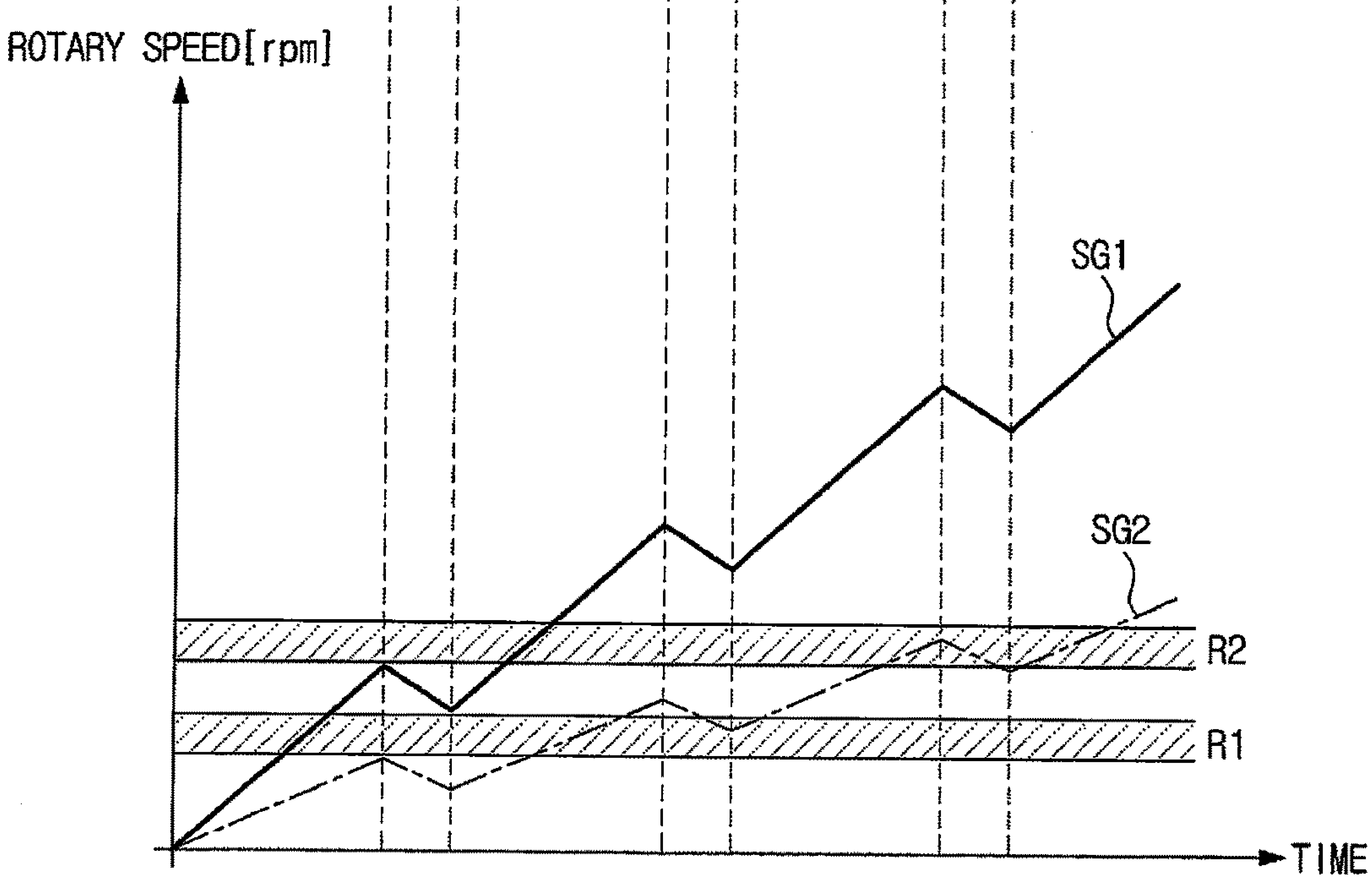


FIG.9C

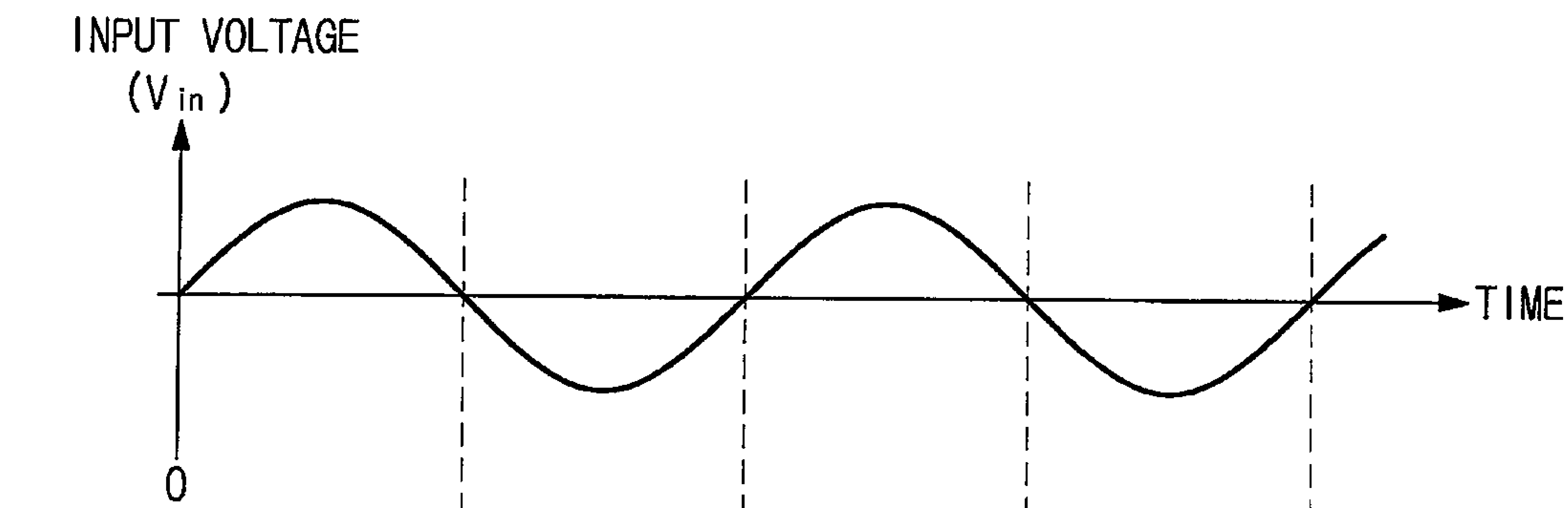


FIG.10A

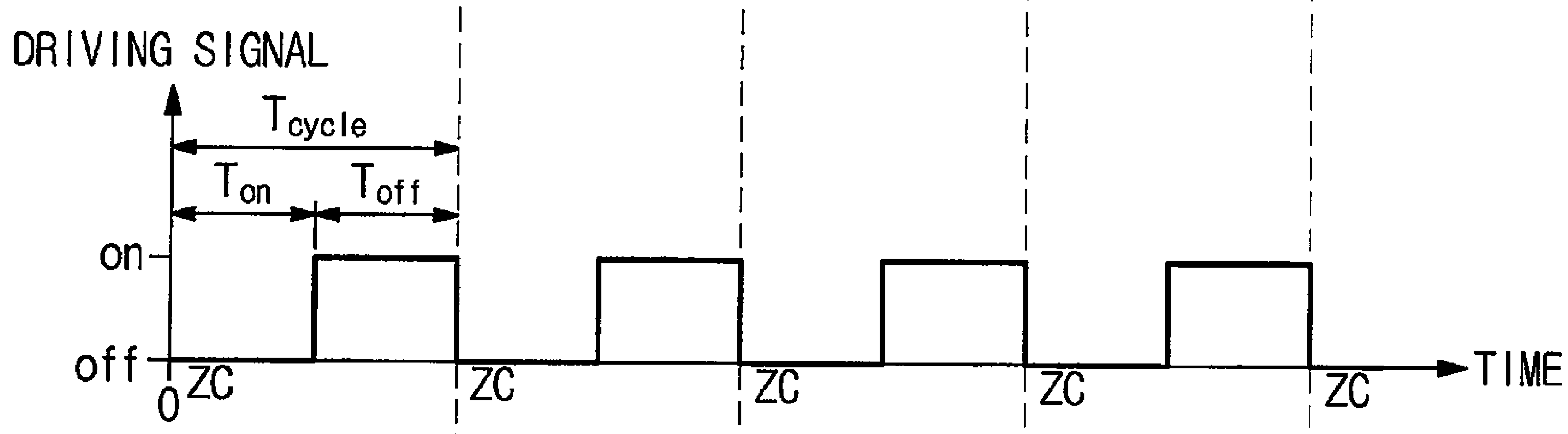


FIG.10B

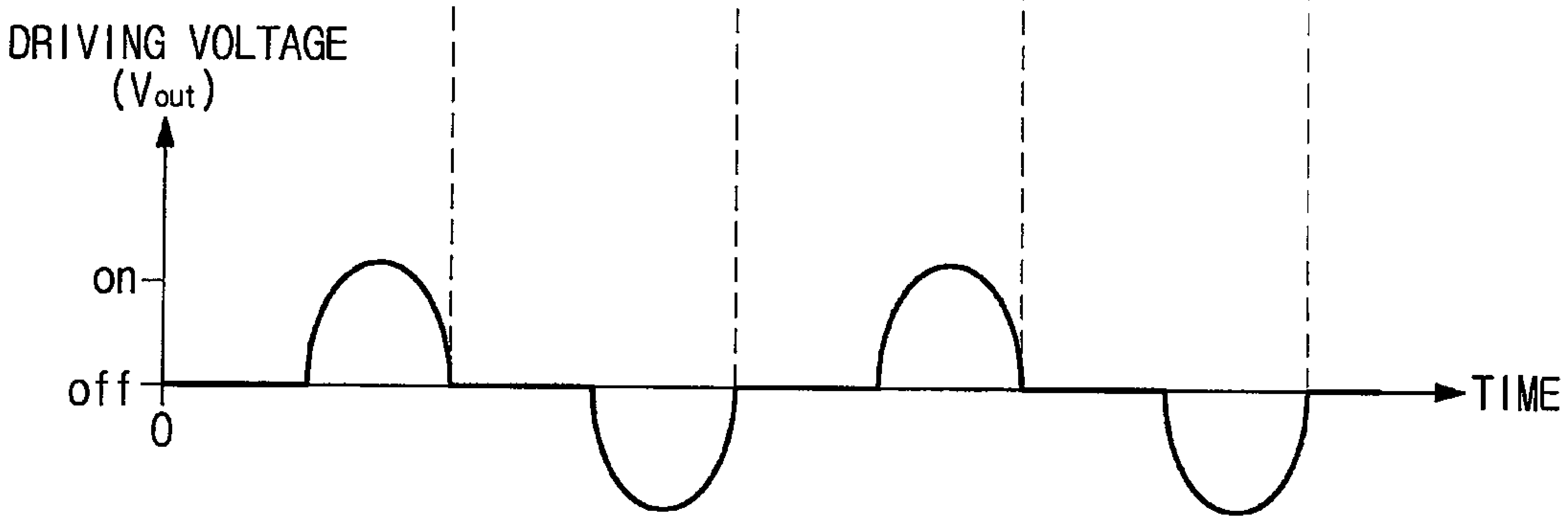


FIG.10C

FIG.11

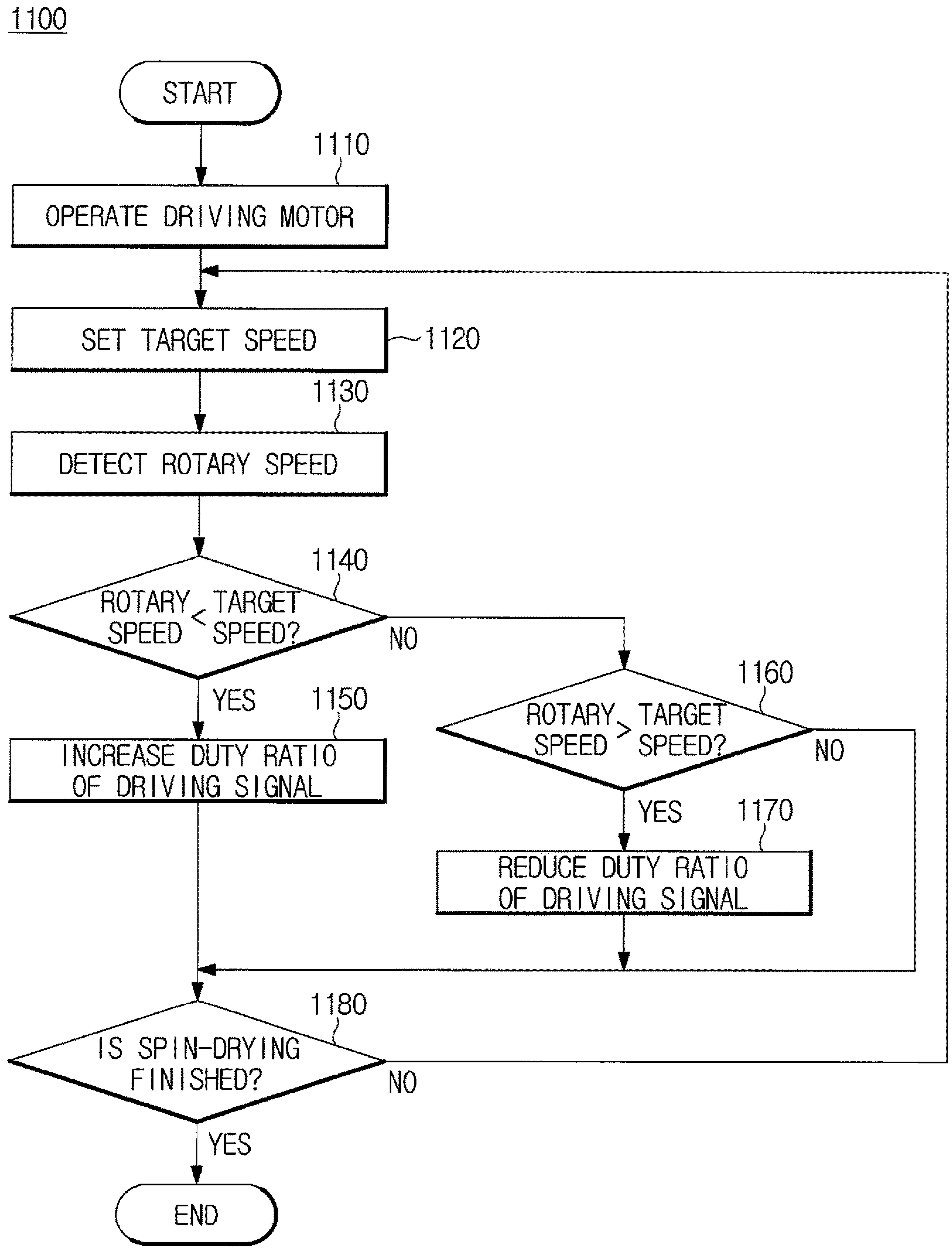
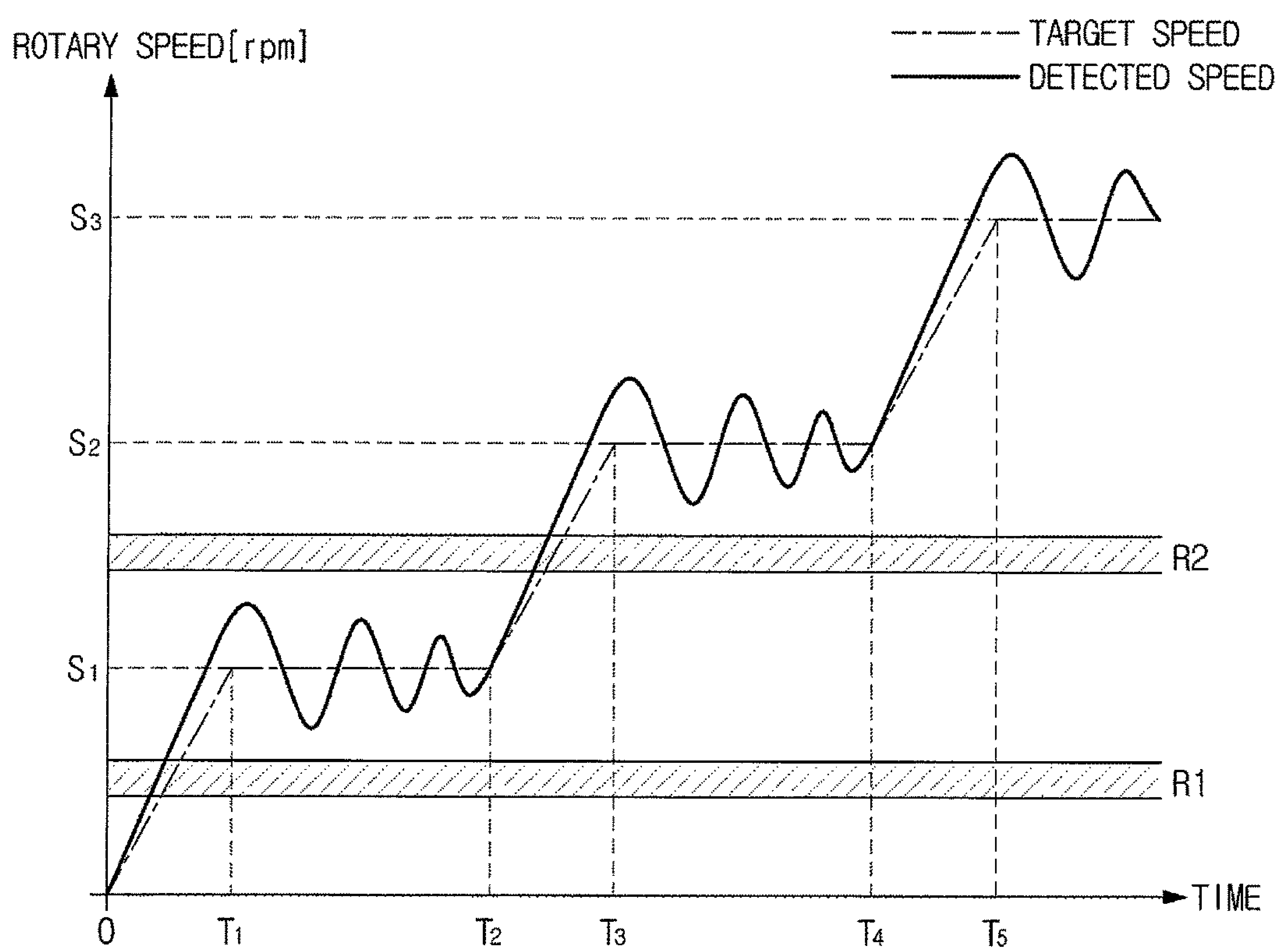

1100
START
1110
OPERATE DRIVING MOTOR
SET TARGET SPEED
1120
1130
DETECT ROTARY SPEED
1140
ROTARY SPEED < TARGET SPEED?
NO
YES
1150
INCREASE DUTY RATIO OF DRIVING SIGNAL
1160
ROTARY SPEED > TARGET SPEED?
NO
YES
1170
REDUCE DUTY RATIO OF DRIVING SIGNAL
1180
IS SPIN-DRYING FINISHED?
NO
YES
END

FIG.12


ROTARY SPEED[rpm]
TARGET SPEED
DETECTED SPEED
S3
S2
S1
R2
R1
0
T1
T2
T3
T4
T5
TIME

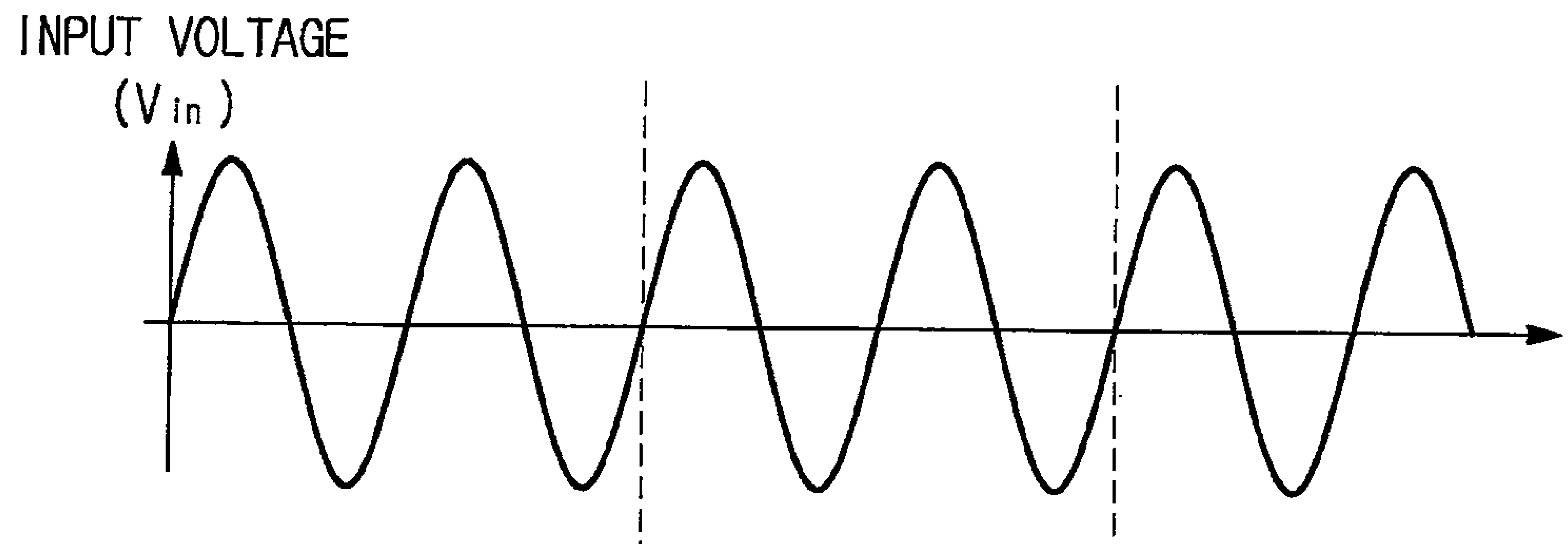


FIG.13A

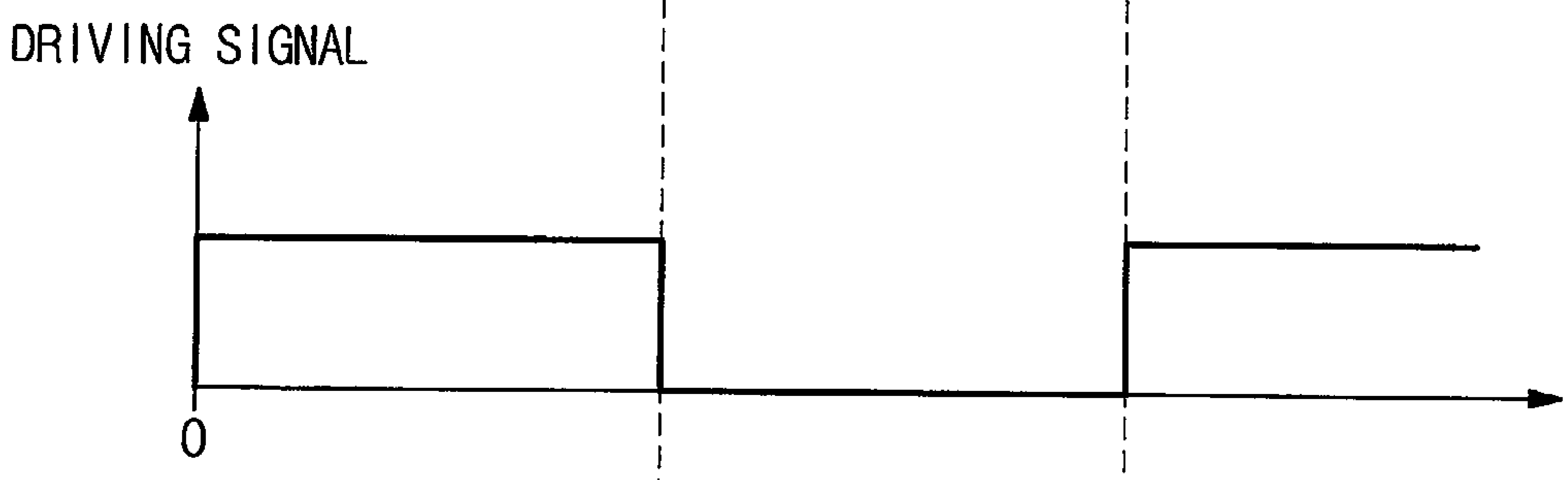


FIG.13B

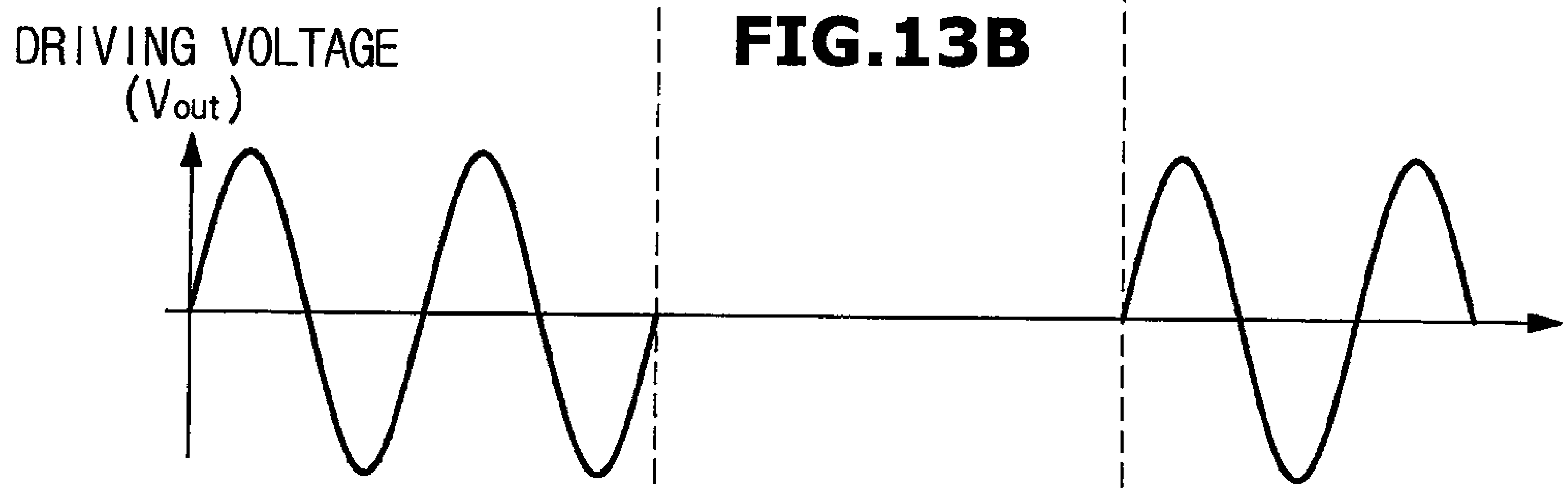


FIG.13C

FIG.14

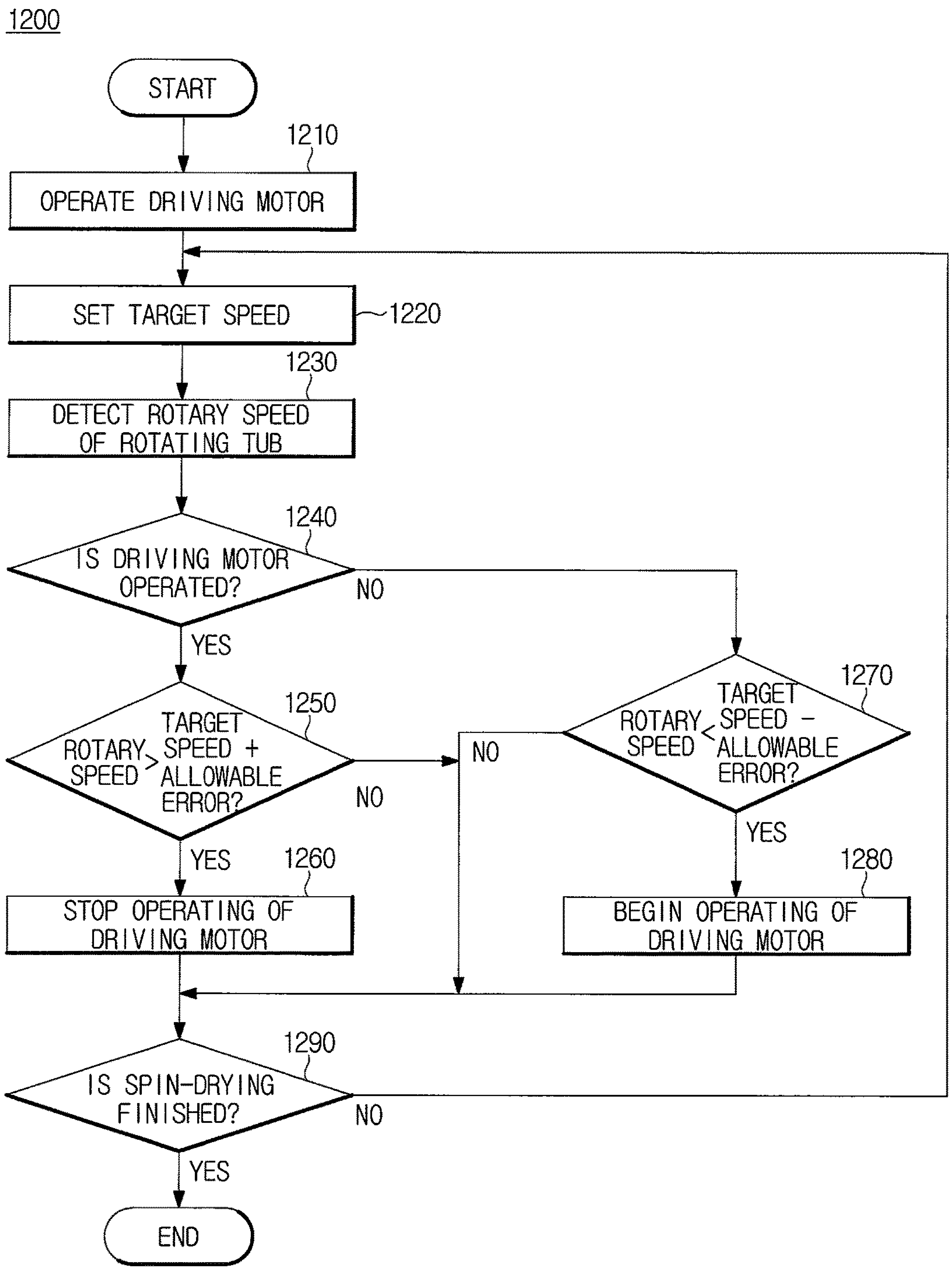
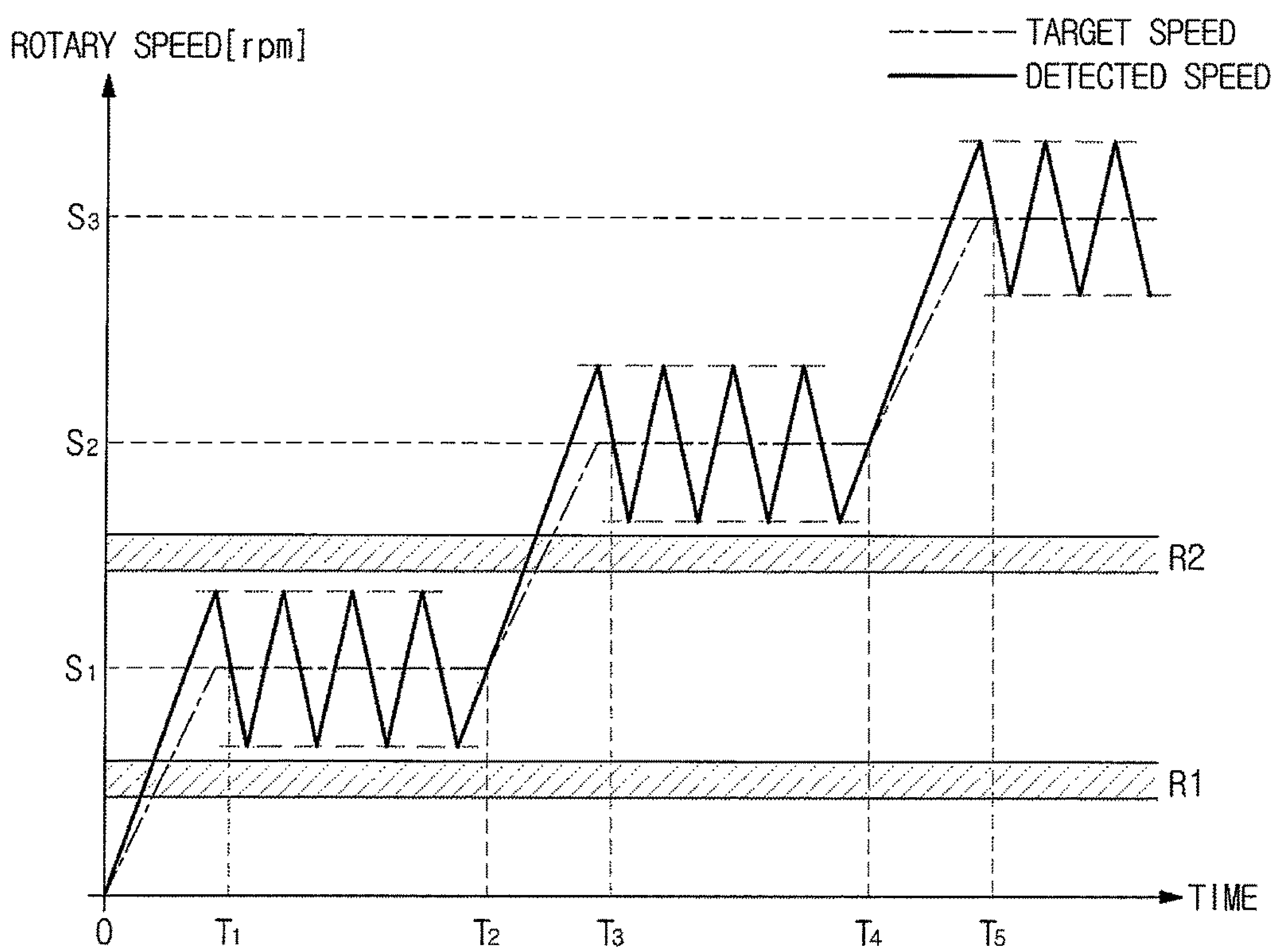

1200
START
1210
OPERATE DRIVING MOTOR
SET TARGET SPEED
1220
1230
DETECT ROTARY SPEED OF ROTATING TUB
1240
IS DRIVING MOTOR OPERATED?
NO
YES
1250
ROTARY SPEED > TARGET SPEED + ALLOWABLE ERROR?
NO
1270
ROTARY SPEED < TARGET SPEED − ALLOWABLE ERROR?
NO
YES
1260
STOP OPERATING OF DRIVING MOTOR
YES
1280
BEGIN OPERATING OF DRIVING MOTOR
1290
IS SPIN-DRYING FINISHED?
NO
YES
END

FIG.15



ROTARY SPEED[rpm]
TARGET SPEED
DETECTED SPEED
S3
S2
S1
R2
R1
TIME
0
T1
T2
T3
T4
T5

FIG.16

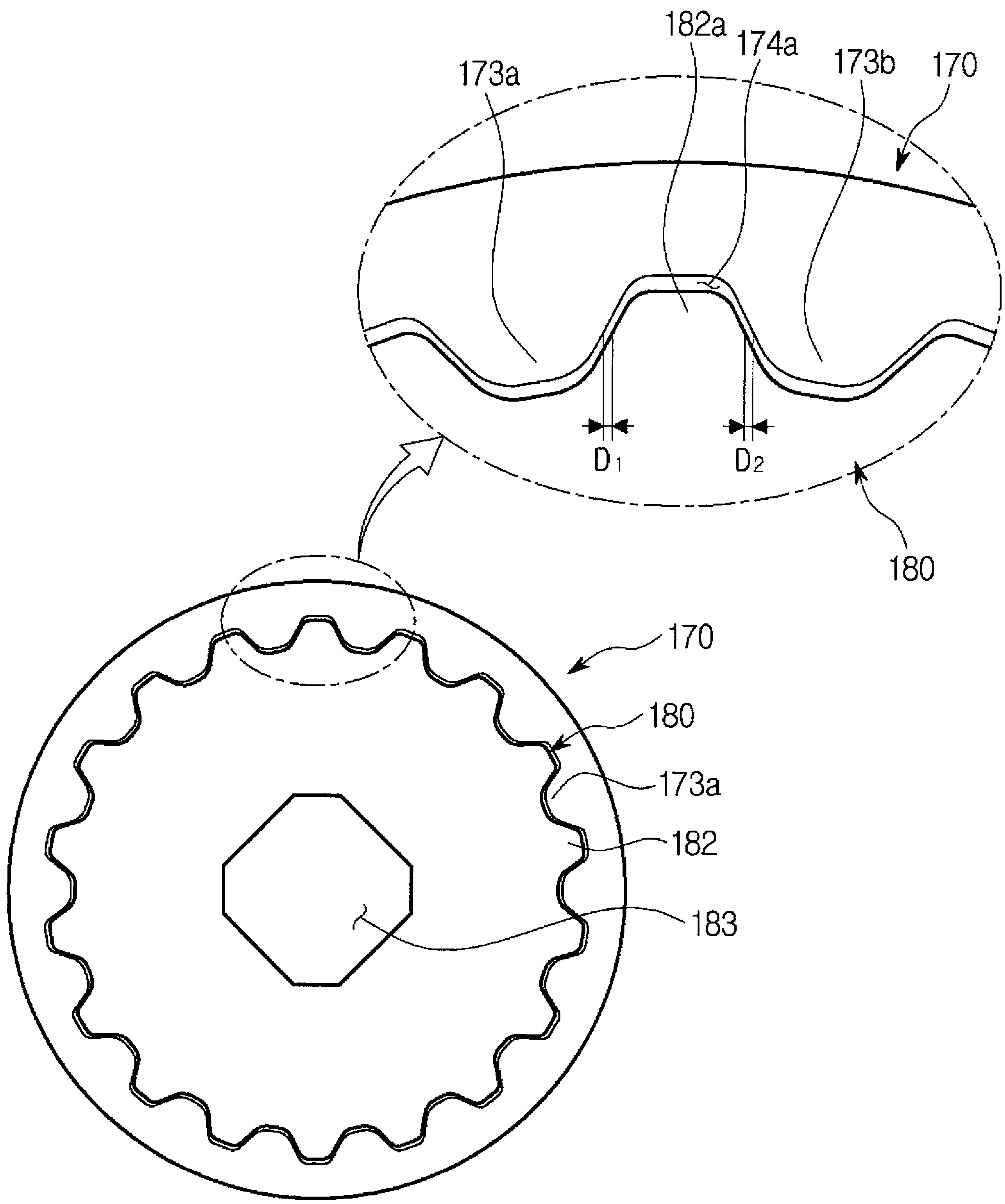


FIG.17

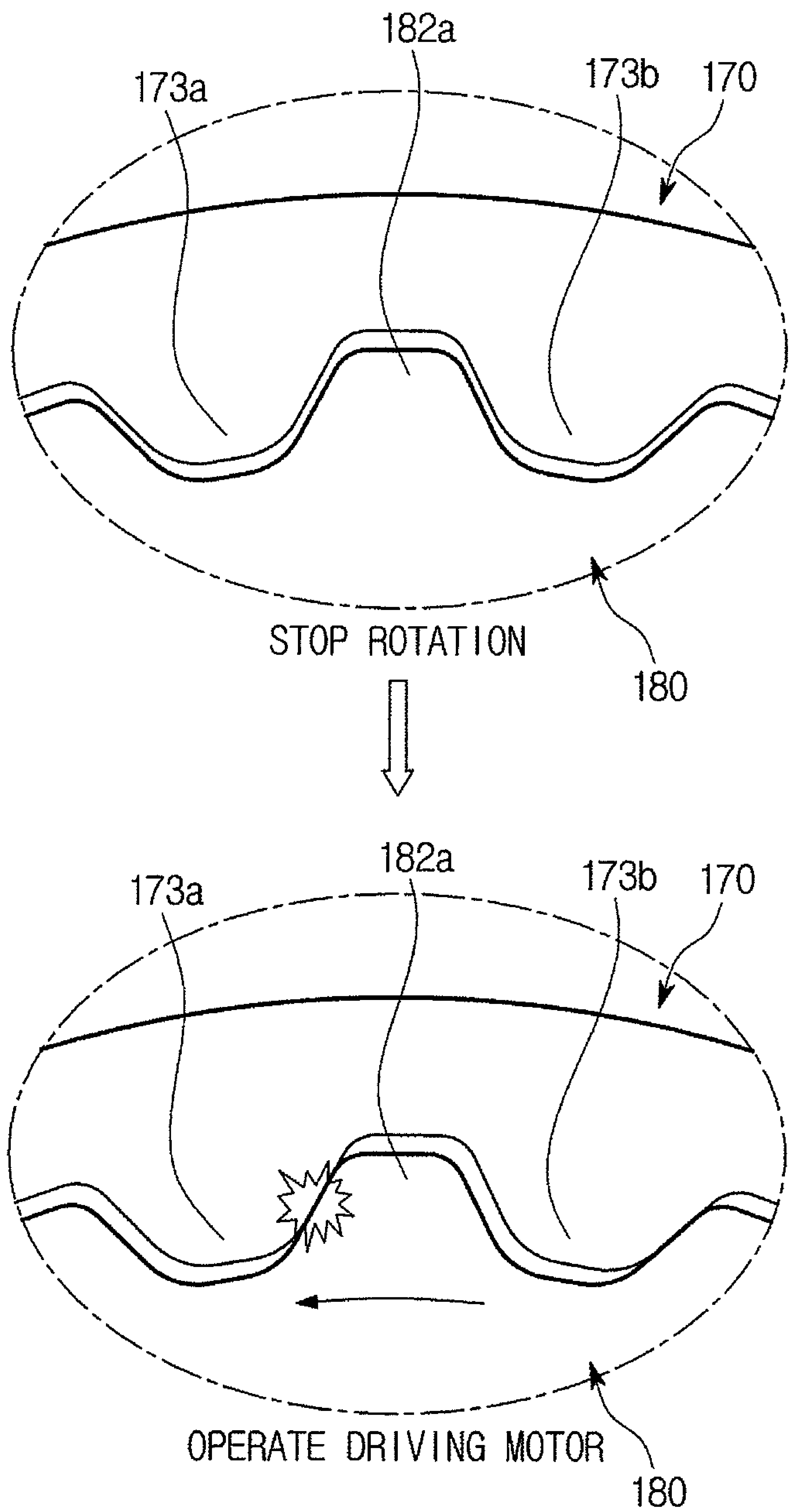

182a
173a
173b
170
180
STOP ROTATION
182a
173a
173b
170
OPERATE DRIVING MOTOR
180

FIG.18

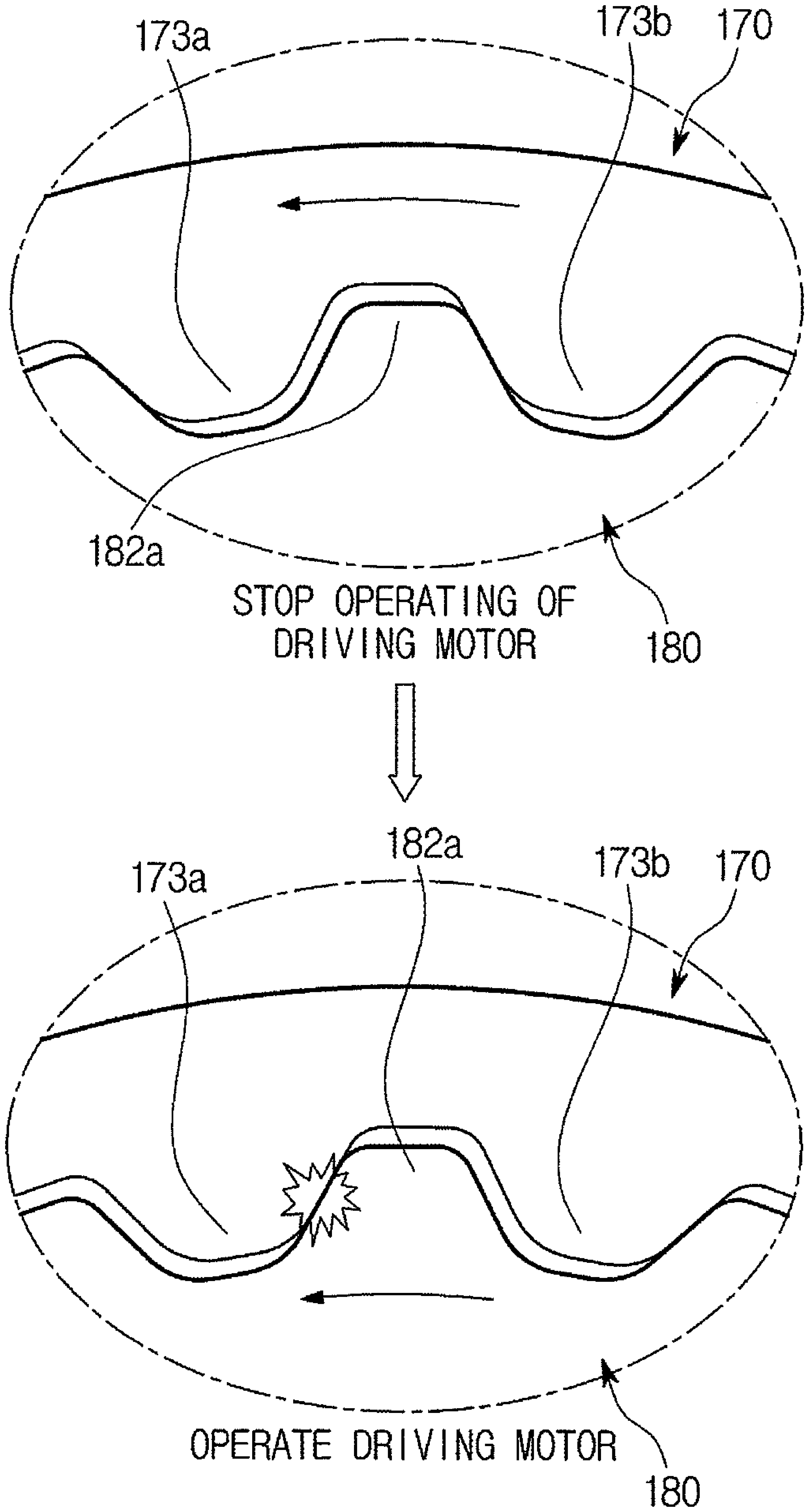
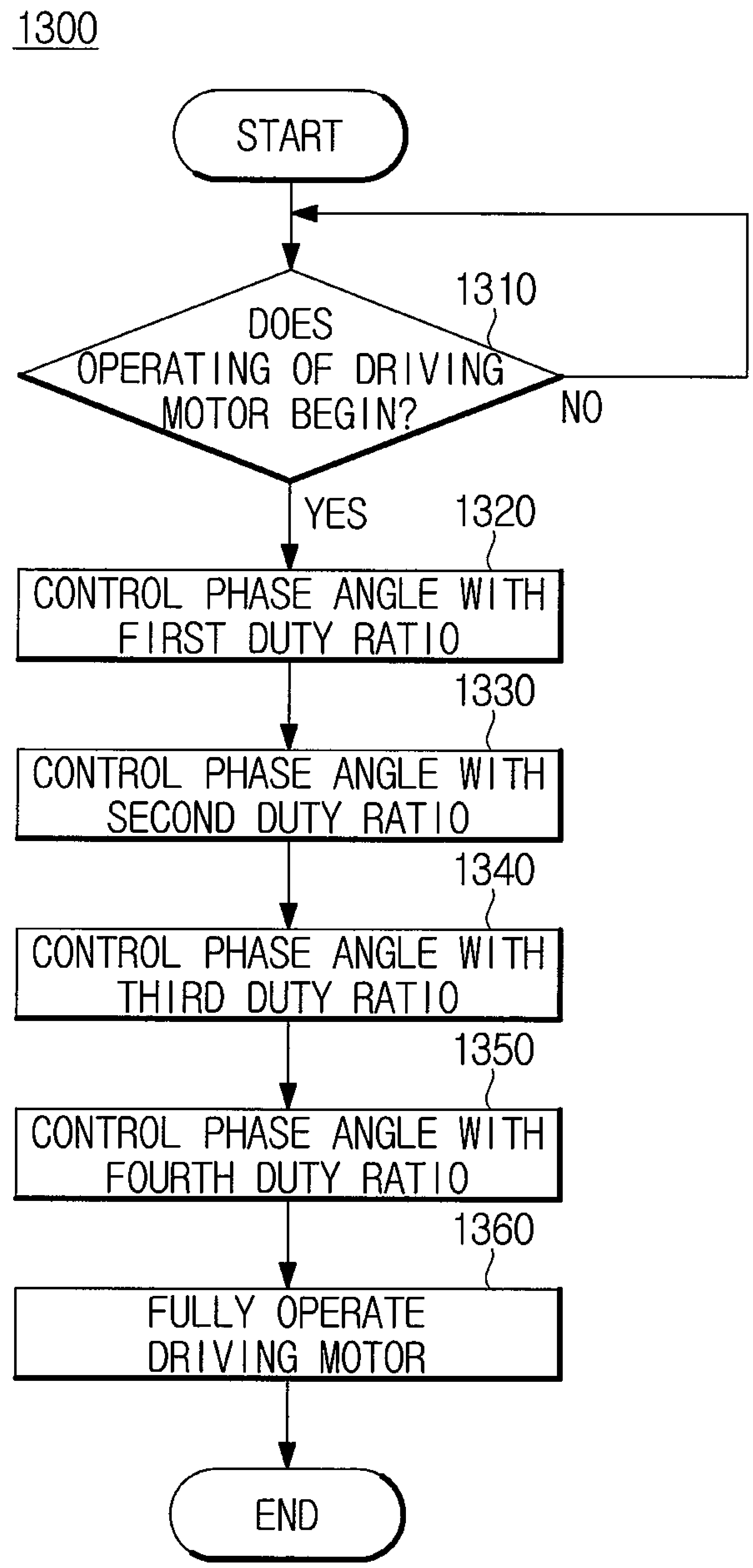

173a
173b
170
182a
180
STOP OPERATING OF DRIVING MOTOR
182a
173a
173b
170
180
OPERATE DRIVING MOTOR

FIG.19



1300
START
1310
DOES OPERATING OF DRIVING MOTOR BEGIN?
NO
YES
1320
CONTROL PHASE ANGLE WITH FIRST DUTY RATIO
1330
CONTROL PHASE ANGLE WITH SECOND DUTY RATIO
1340
CONTROL PHASE ANGLE WITH THIRD DUTY RATIO
1350
CONTROL PHASE ANGLE WITH FOURTH DUTY RATIO
1360
FULLY OPERATE DRIVING MOTOR
END

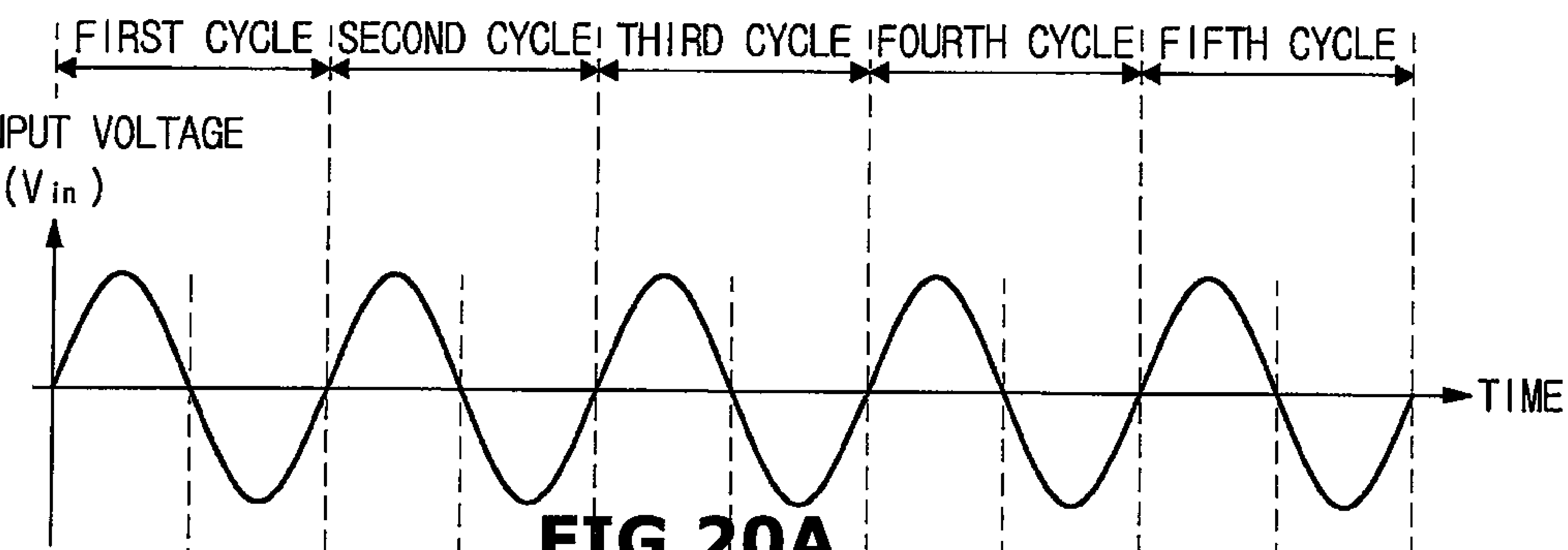


FIG.20A

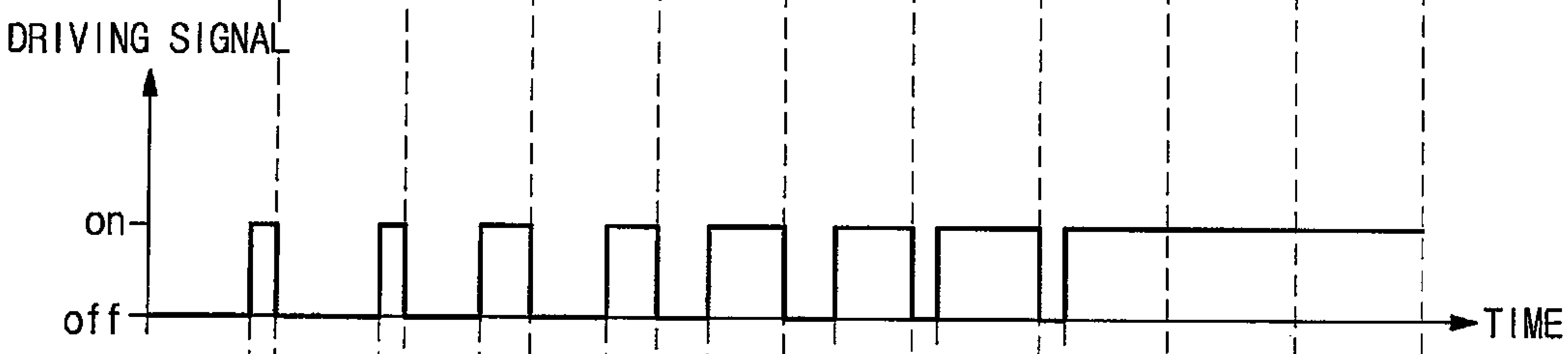


FIG.20B

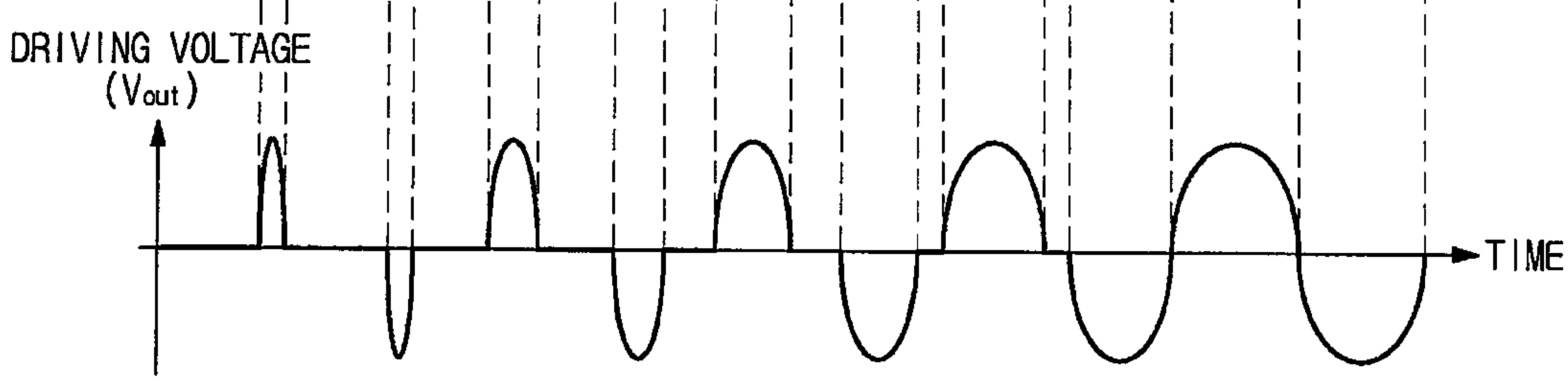


FIG.20C

FIG.21

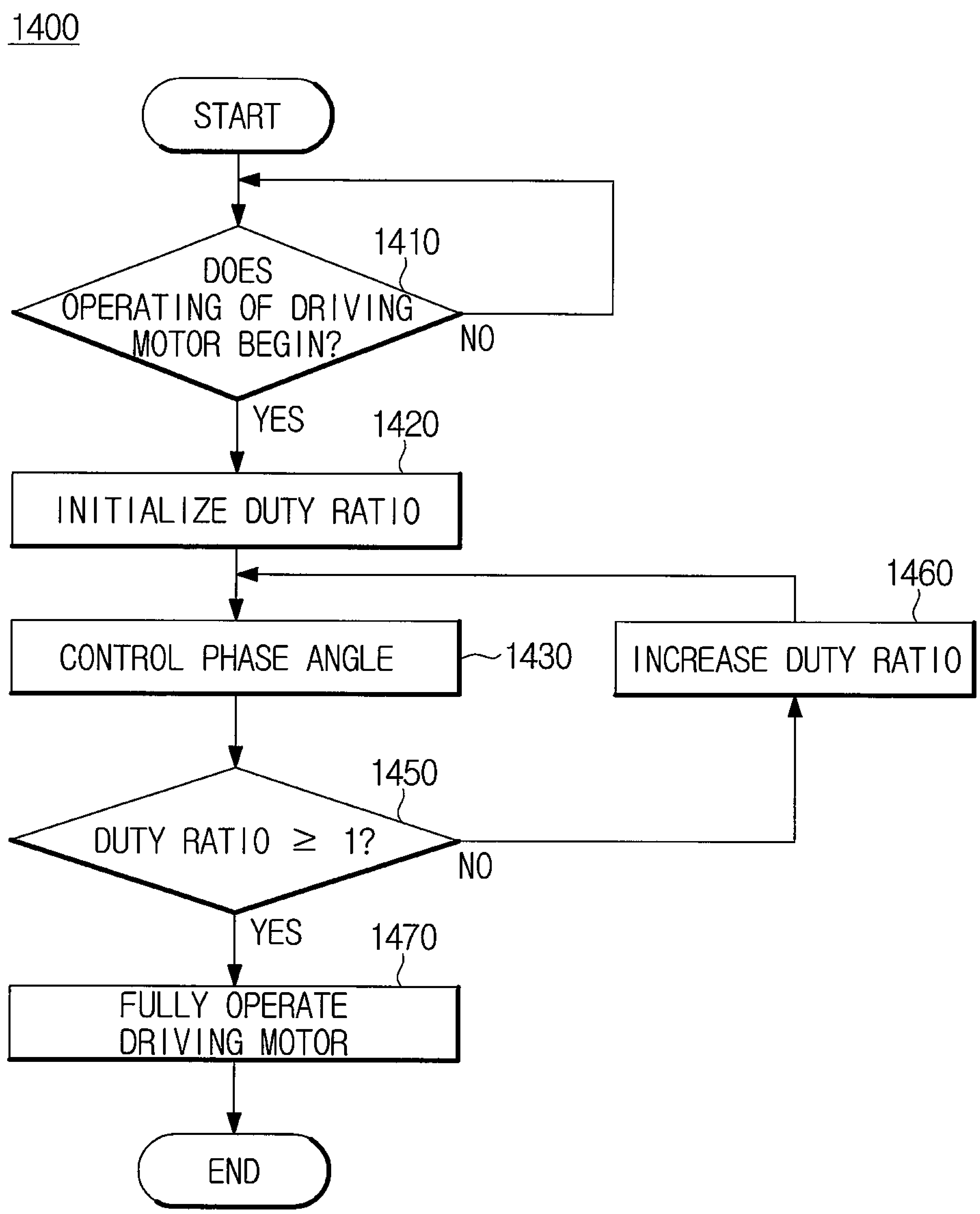

1400
START
DOES OPERATING OF DRIVING MOTOR BEGIN?
1410
NO
YES
1420
INITIALIZE DUTY RATIO
1460
CONTROL PHASE ANGLE
1430
INCREASE DUTY RATIO
1450
DUTY RATIO ≥ 1?
NO
YES
1470
FULLY OPERATE DRIVING MOTOR
END

FIG.22

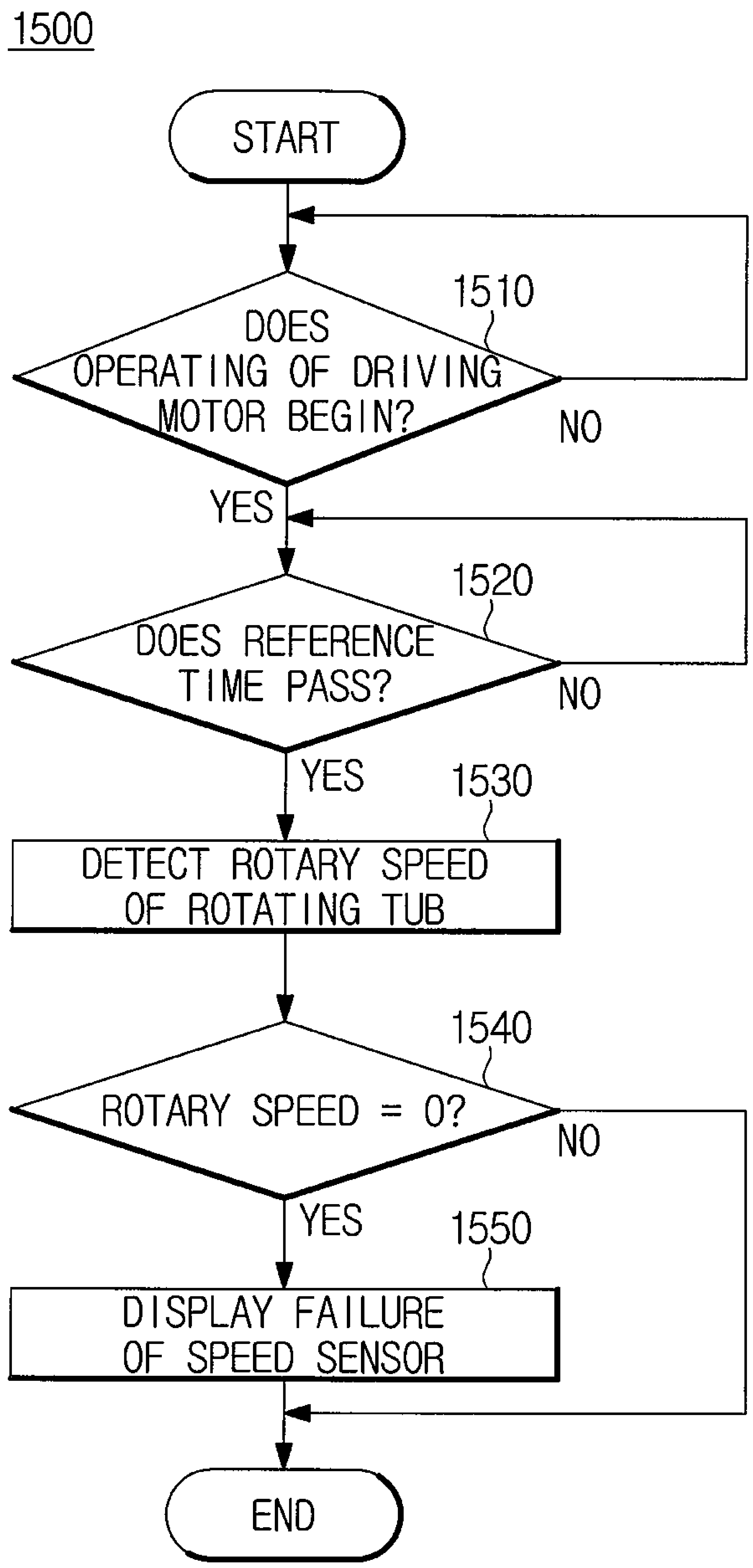

1500
START
DOES OPERATING OF DRIVING MOTOR BEGIN?
1510
NO
YES
DOES REFERENCE TIME PASS?
1520
NO
YES
1530
DETECT ROTARY SPEED OF ROTATING TUB
ROTARY SPEED = 0?
1540
NO
YES
1550
DISPLAY FAILURE OF SPEED SENSOR
END

FIG.23

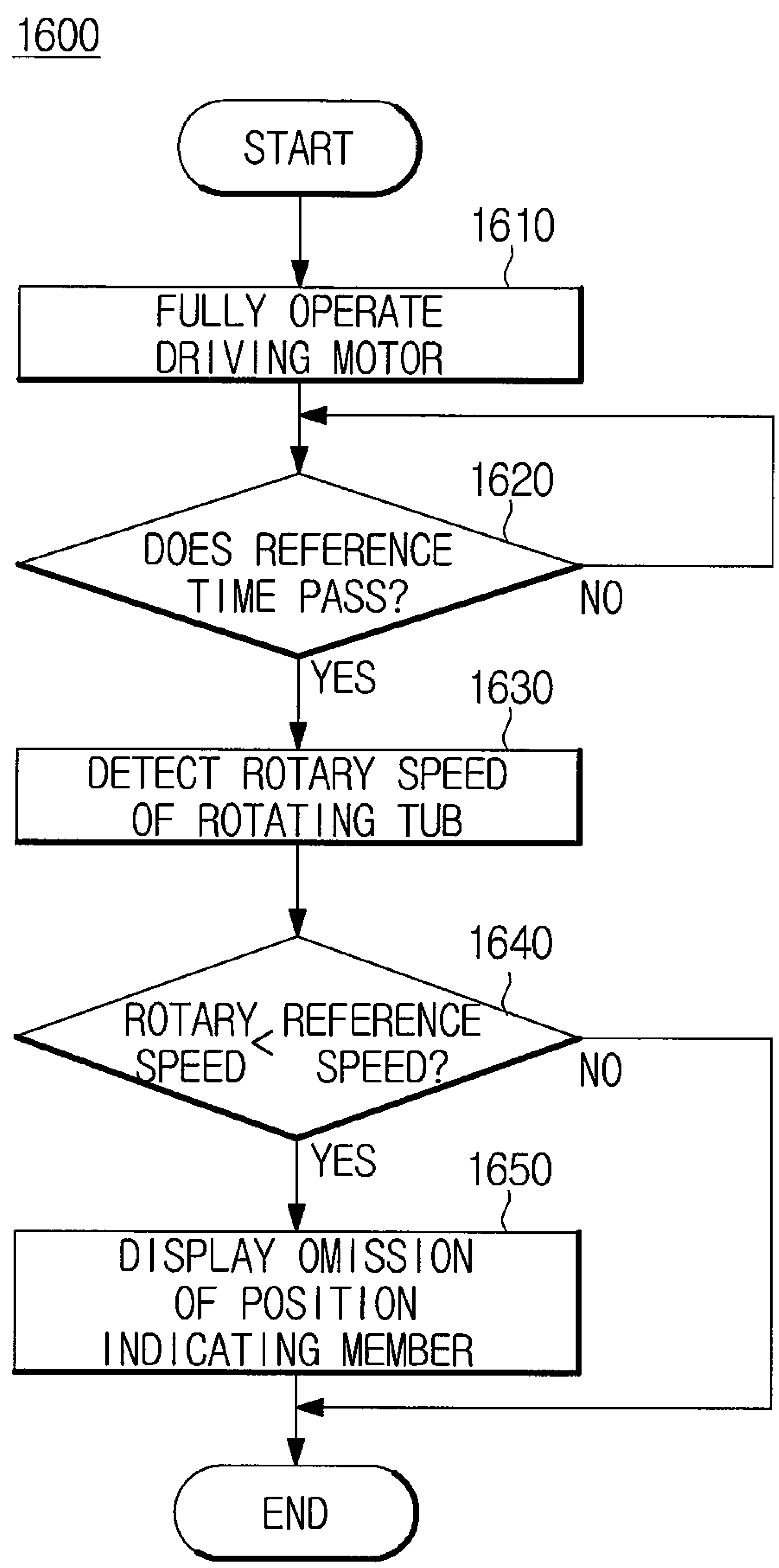

1600
START
1610
FULLY OPERATE DRIVING MOTOR
1620
DOES REFERENCE TIME PASS?
NO
YES
1630
DETECT ROTARY SPEED OF ROTATING TUB
1640
ROTARY SPEED < REFERENCE SPEED?
NO
YES
1650
DISPLAY OMISSION OF POSITION INDICATING MEMBER
END

FIG.24

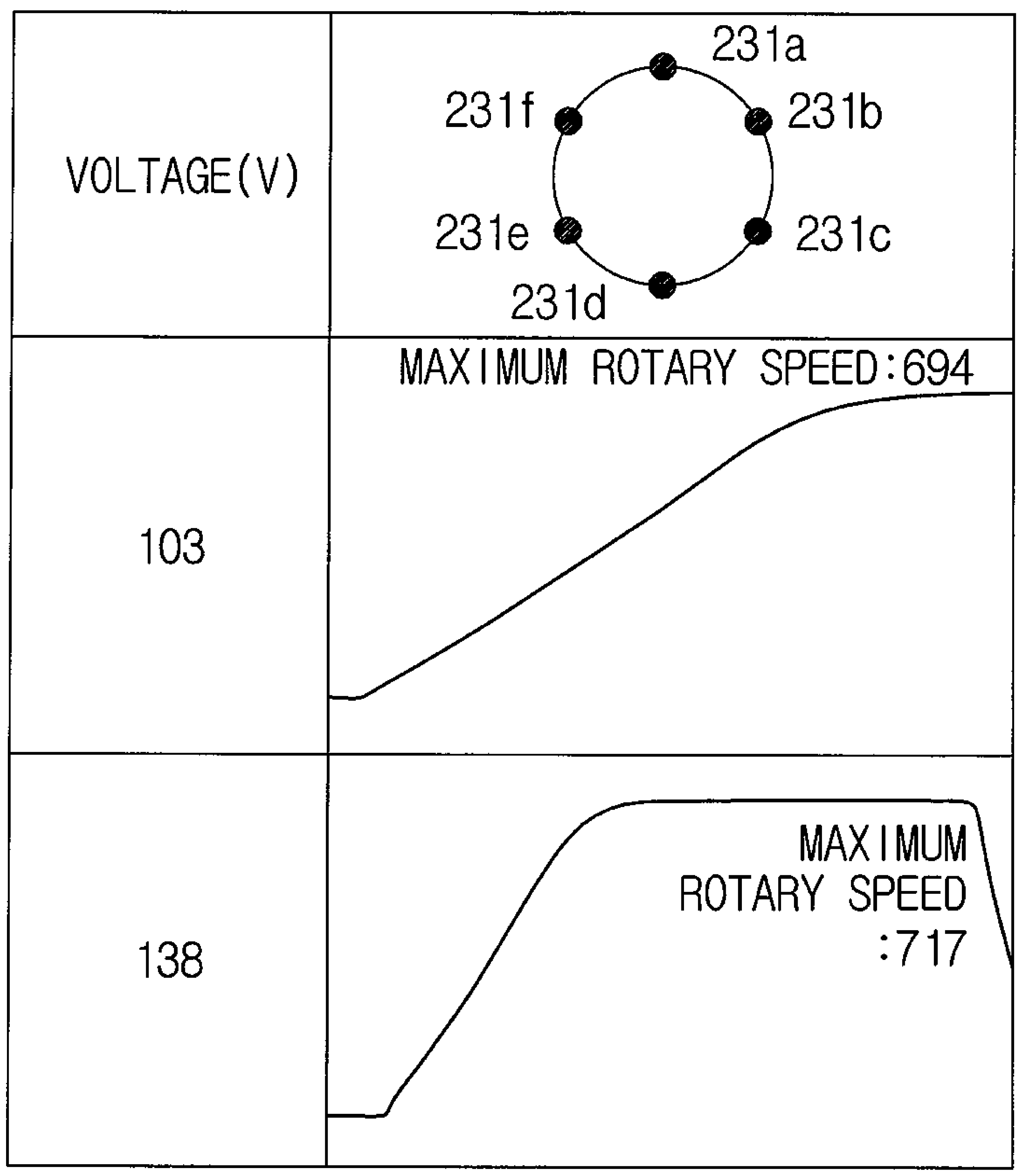

VOLTAGE(V)
231a
231b
231c
231d
231e
231f
103
MAXIMUM ROTARY SPEED:694
138
MAXIMUM
ROTARY SPEED
:717

FIG.25

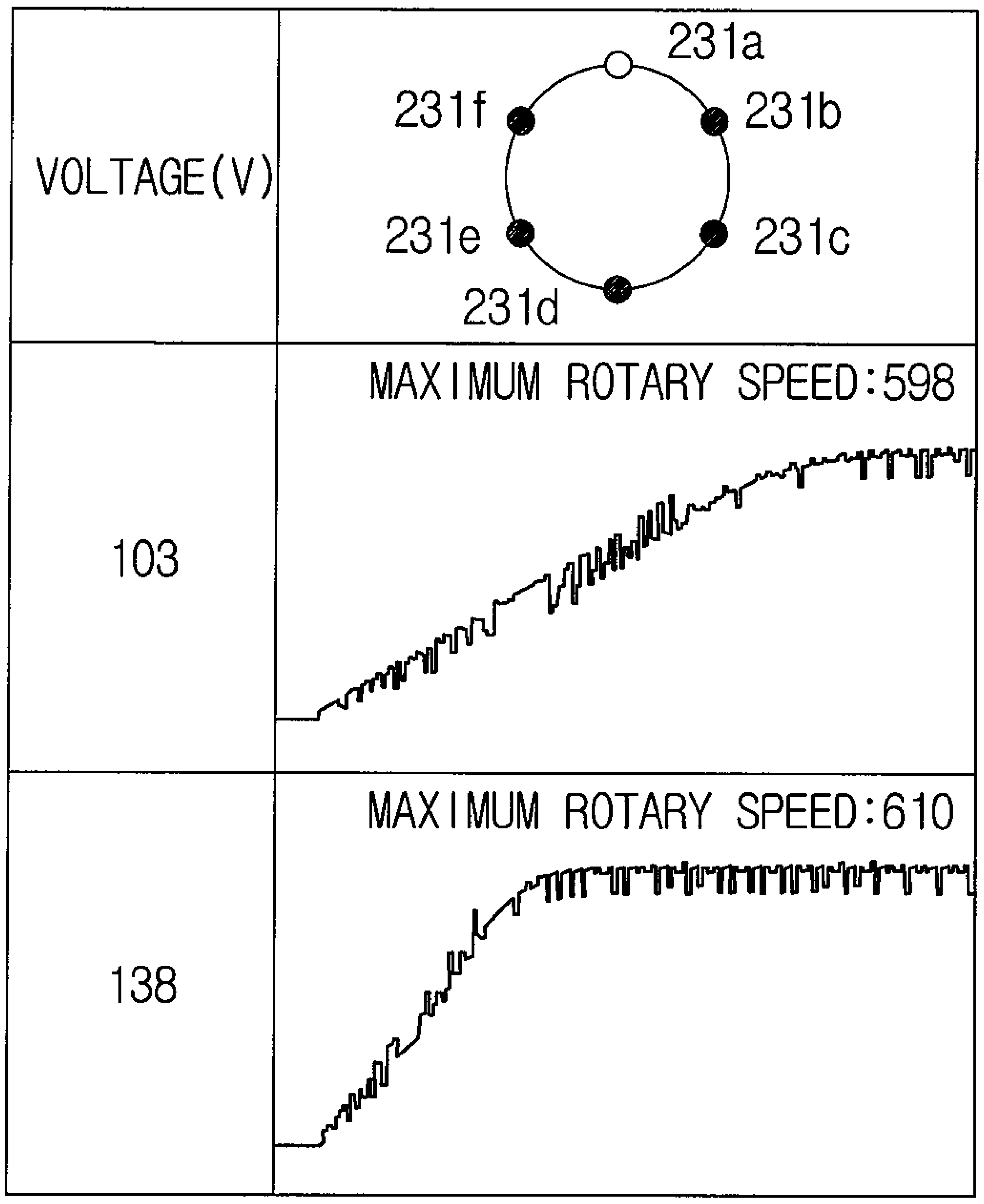

VOLTAGE(V)
231a
231b
231c
231d
231e
231f
103
MAXIMUM ROTARY SPEED:598
138
MAXIMUM ROTARY SPEED:610

FIG. 26

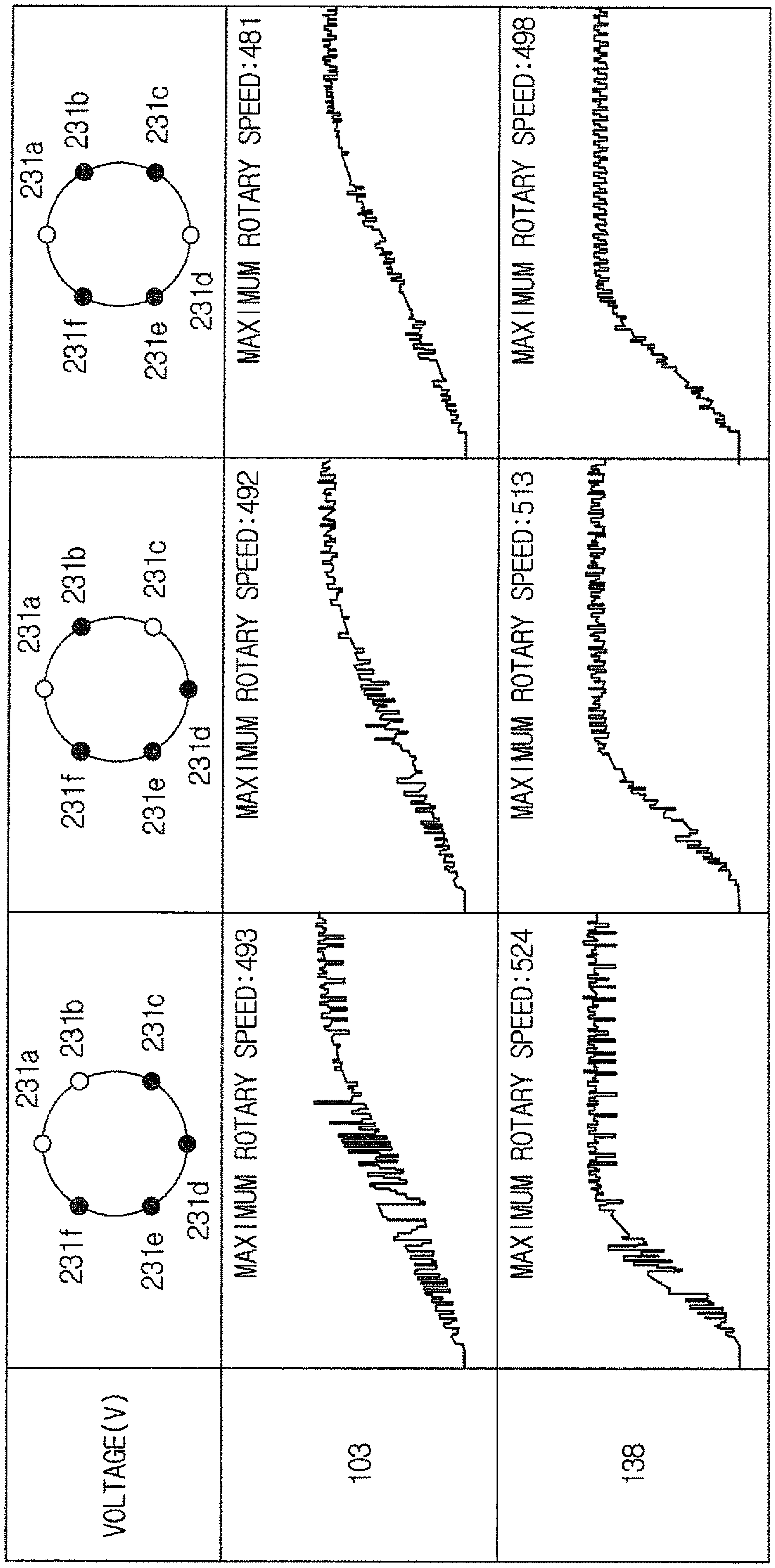

VOLTAGE(V)
103
138
231a
231b
231c
231d
231e
231f
MAXIMUM ROTARY SPEED:493
MAXIMUM ROTARY SPEED:524
MAXIMUM ROTARY SPEED:492
MAXIMUM ROTARY SPEED:513
MAXIMUM ROTARY SPEED:481
MAXIMUM ROTARY SPEED:498

FIG. 27

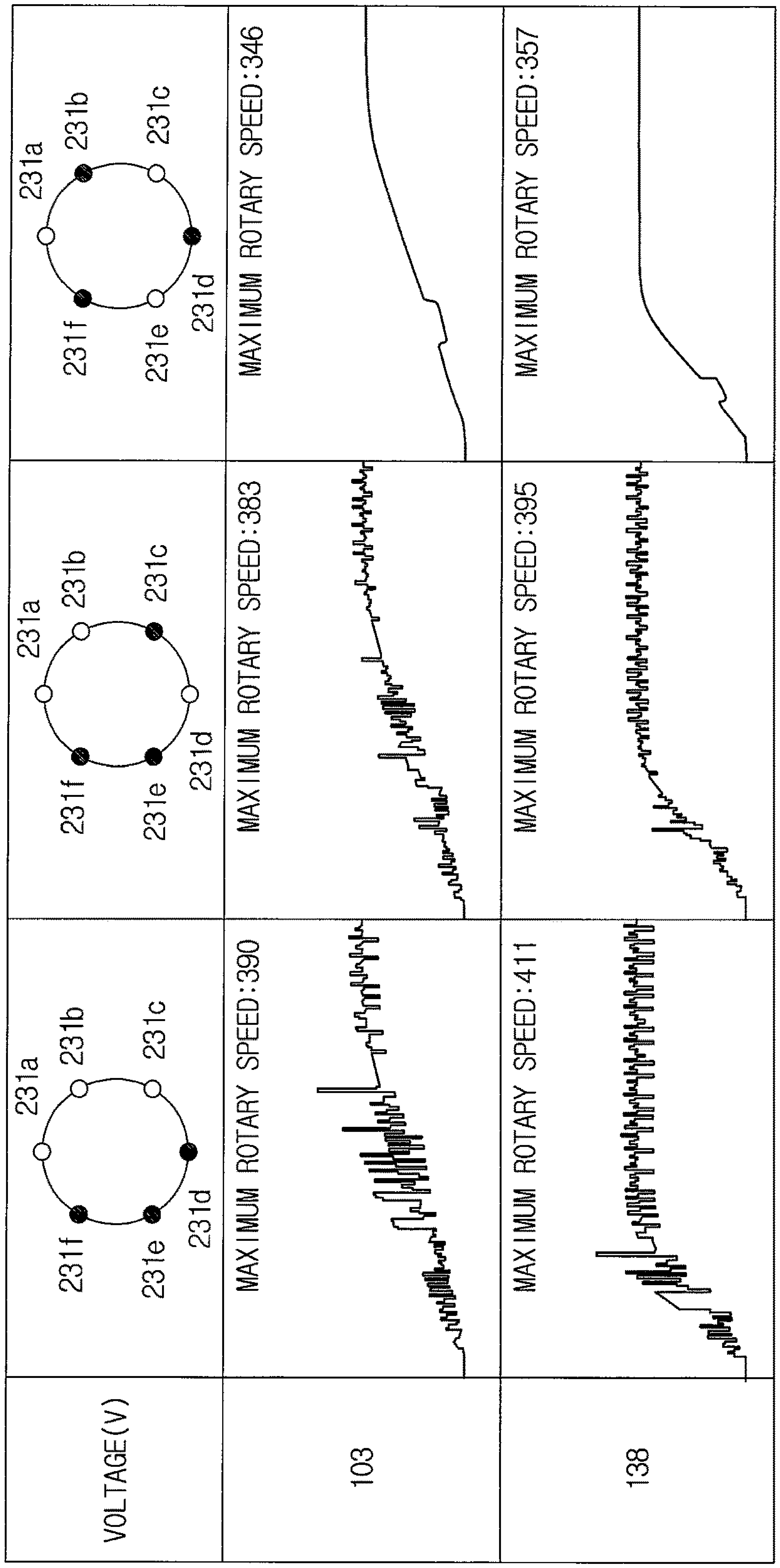

VOLTAGE(V)
103
138
231a
231b
231c
231d
231e
231f
MAXIMUM ROTARY SPEED:390
MAXIMUM ROTARY SPEED:383
MAXIMUM ROTARY SPEED:346
MAXIMUM ROTARY SPEED:411
MAXIMUM ROTARY SPEED:395
MAXIMUM ROTARY SPEED:357

FIG. 28

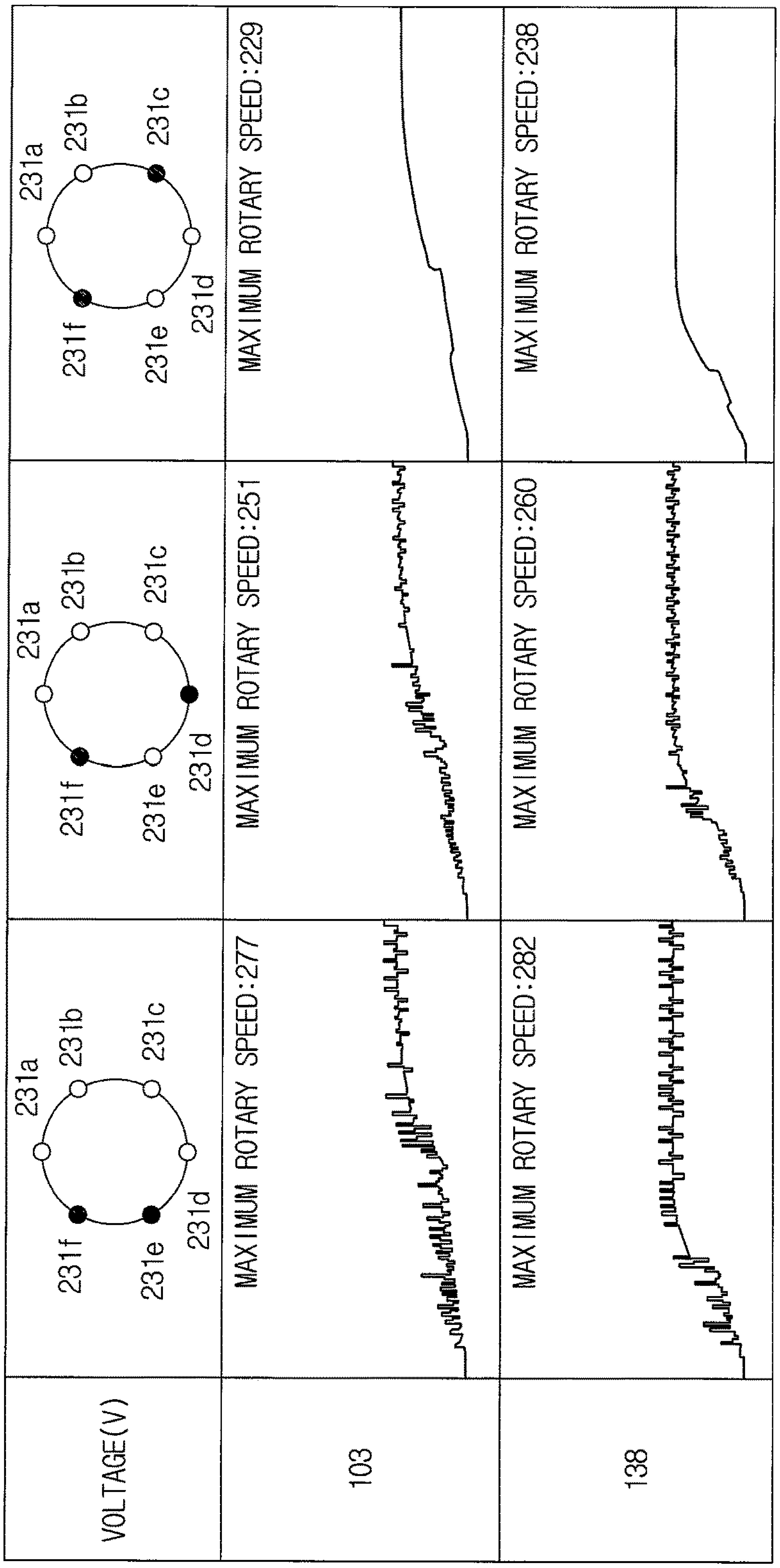
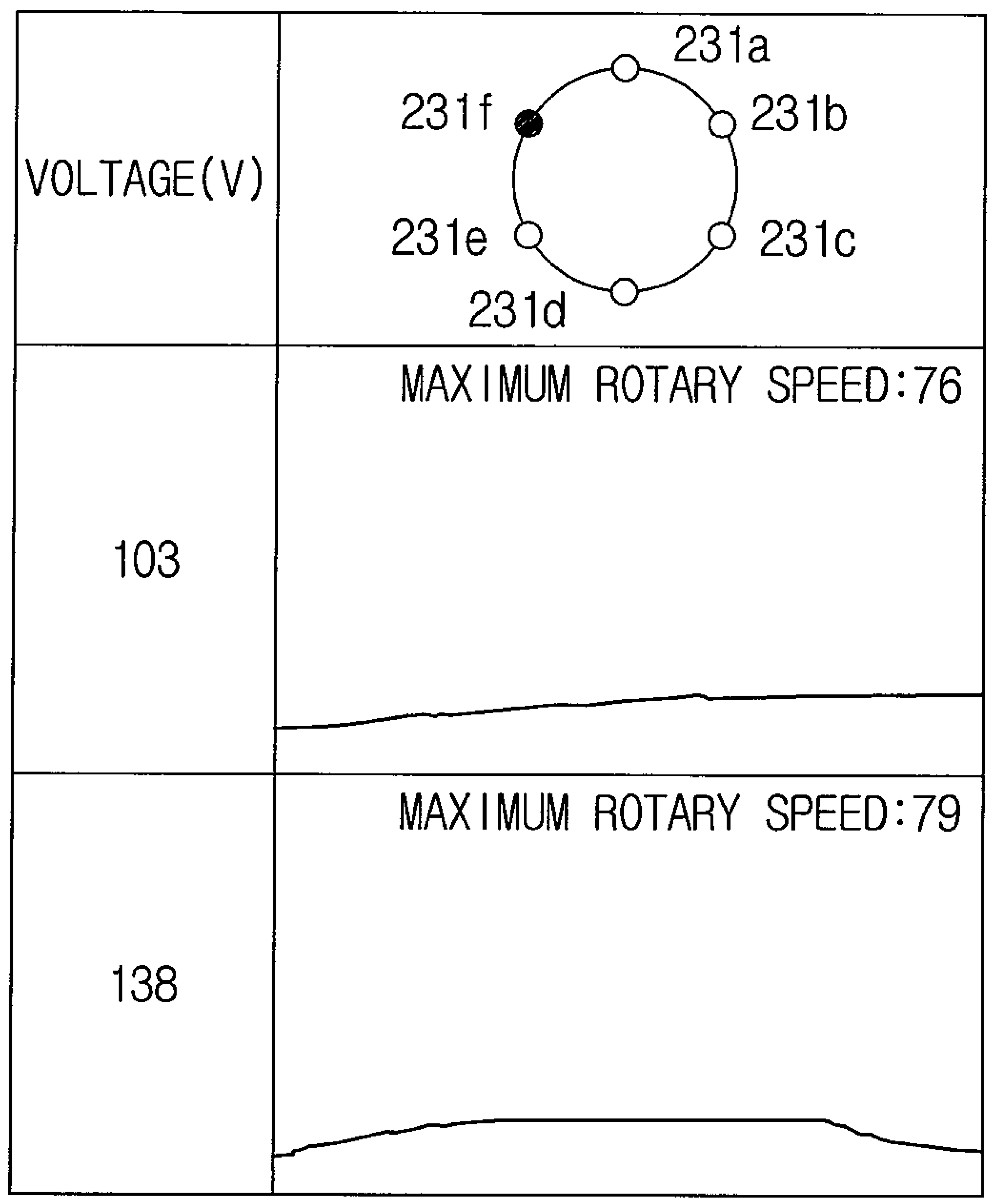

VOLTAGE(V)
103
138
231a
231b
231c
231d
231e
231f
MAXIMUM ROTARY SPEED:277
MAXIMUM ROTARY SPEED:282
MAXIMUM ROTARY SPEED:251
MAXIMUM ROTARY SPEED:260
MAXIMUM ROTARY SPEED:229
MAXIMUM ROTARY SPEED:238

FIG.29


VOLTAGE(V)
231a
231b
231c
231d
231e
231f
103
MAXIMUM ROTARY SPEED:76
138
MAXIMUM ROTARY SPEED:79

WASHING MACHINE AND METHOD OF CONTROLLING THE SAME USING AN AC MOTOR

CROSS-REFERENCE TO RELATED APPLICATION AND CLAIM OF PRIORITY

The present application is related to and claims the benefit of Korean Patent Application No. 10-2015-0015343, filed on Jan. 30, 2015 in the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

Embodiments of the present disclosure relate to a washing machine and a method of controlling the same, and more particularly, to a washing machine which includes an alternating current (AC) motor and a method of controlling the washing machine.

BACKGROUND

Generally, washing machines are apparatuses which wash laundry using a frictional force between the laundry and water and can be classified into front-loading type washing machines and top-loading type washing machines.

In front-loading type washing machines, washing is performed using a drop of laundry while a rotating tub which accommodates the laundry rotates. In top-loading type washing machines, a rotating tub in which laundry is accommodated and a pulsator which generates a water current at a bottom of the rotating tub are provided together and washing is performed using the water current generated by the pulsator.

Also, in all front-loading type washing machines and top-loading type washing machines, laundry is spin-dried using a centrifugal force generated by rotation of a rotating tub.

As described above, washing machines operate using rotation of a rotating tub or a pulsator and generally use a motor as a device for providing torque to the rotating tub or pulsator.

As described above, motors generally used in washing machines can be classified into control type motors, so-called servo motors, which precisely control a rotary speed of a motor and a non-control type motors which do not control a rotary speed of a motor.

Control type motors each include a speed sensor which detects a rotary speed of a motor and a current sensor which detects a driving current of the motor and precisely control the driving current depending on the detected rotary speed of the motor. Control type motors described above can each precisely control the rotary speed of the motor regardless of load.

On the contrary, in general, non-control type motors each merely control rotation of a motor through a turn-on time in which power is supplied to the motor and a turn-off time in which power supply to the motor is cut off. Non-control type motors described above are relatively low-priced.

When a washing machine includes a non-control type motor, it is difficult to precisely a rotary speed of the motor. Thus, a resonance phenomenon can continuously occur during a spin-drying operation. Here, the resonance phenomenon means a phenomenon in which a vibration frequency of a rotating tub coincides with a rotation frequency caused by the motor in the spin-drying operation and thus a rotating tub violently vibrates.

In general washing machines using a non-control type motor, since rotation of a rotating tub is controlled only using a turn-on time and a turn-off time of a motor, it is difficult for a rotary speed of the rotating tub to be deviated from a resonance speed of the rotating tub.

SUMMARY

To address the above-discussed deficiencies, it is a primary object to provide, for use in a washing machine which includes a non-control type motor while minimizing a resonance phenomenon during a spin-drying operation.

It is another aspect of the present disclosure to provide a washing machine which includes a clutch assembly while minimizing noise and vibration which occur while a driving motor operates.

It is still another aspect of the present disclosure to provide a washing machine which includes a speed detector while detecting a failure of the speed detector.

Additional aspects of the disclosure will be set forth in part in the description which follows and, in part, will be obvious from the description, or can be learned by practice of the disclosure.

In accordance with one aspect of the present disclosure, a washing machine includes an alternating current (AC) motor which generates torque, a clutch assembly which selectively transfers the torque to a rotating tub and a pulsator, a speed detector which detects a rotary speed of the clutch assembly, and a controller which repetitively performs operating and stopping the operating of the AC motor based on a predetermined target speed and the rotary speed of the clutch assembly during a spin-drying operation. Here, the controller gradually increases the torque of the AC motor while operating the AC motor.

The controller can control a phase angle of AC power supplied from an external power supply and can supply the AC power controlled in phase angle to the AC motor while operating the AC motor.

The controller can supply at least a part of one cycle of an AC current supplied from the external power supply to the AC motor while operating the AC motor.

The washing machine can further include a driving switch unit which conducts or cuts off the power supplied from the external power supply to the AC motor.

The controller can turn on the driving switch unit for a conduction time in one cycle of the AC power supplied from the external power supply while operating the AC motor.

The controller can gradually increase the conduction time while operating the AC motor.

The controller can stop the operating of the AC motor when the rotary speed is greater than a sum of the target speed and an allowable error while operating the AC motor.

The controller can begin the operating of the AC motor when the rotary speed is smaller than a difference between the target speed and an allowable error while stopping the operating of the AC motor.

The target speed can vary according to a time in which the spin-drying operation is performed.

The speed detector can include a position indicating member which rotates together with the clutch assembly and a speed sensor which detects the position indicating member and outputs an electric signal corresponding to whether the position indicating member is detected.

The controller can warn a user of a failure of the speed sensor when the rotary speed is "0" after the AC motor is operated.

The controller can warn a user of omission of the position indicating member when the rotary speed is smaller than a predetermined reference speed after the AC motor is fully operated.

In accordance with another aspect of the present disclosure, a method of controlling a washing machine includes operating an AC motor which generates torque during a spin-drying operation, detecting a rotary speed of a clutch assembly which transfers the torque to a rotating tub and a pulsator, and repetitively performing operating and stopping the operating of the AC motor based on a predetermined target speed and the rotary speed of the clutch assembly during the spin-drying operation. Here, the operating of the AC motor includes gradually increasing the torque of the AC motor.

The gradually increasing of the torque of the AC motor can include controlling a phase angle of AC power supplied from an external power supply and supplying the AC power controlled in phase angle to the AC motor.

The supplying of the AC power controlled in phase angle to the AC motor can include supplying at least a part of one cycle of an AC current supplied from the external power supply to the AC motor.

The repetitively performing the operating and stopping of the operating of the AC motor can include stopping the operating of the AC motor when the rotary speed is greater than a sum of the target speed and an allowable error while operating the AC motor.

The repetitively performing the operating and stopping of the operating of the AC motor can include beginning the operating of the AC motor when the rotary speed is smaller than a difference between the target speed and an allowable error while stopping the operating of the AC motor.

The target speed may vary according to a time in which the spin-drying operation is performed.

The method may further include warning a user of a failure of a speed sensor which detects the rotary speed of the clutch assembly when the rotary speed is "0" after the AC motor is operated.

The method may further include warning a user of a failure of a speed sensor which detects the rotary speed of the clutch assembly when the rotary speed is smaller than a predetermined reference speed after the AC motor is fully operated.

Before undertaking the DETAILED DESCRIPTION below, it may be advantageous to set forth definitions of certain words and phrases used throughout this patent document: the terms "include" and "comprise," as well as derivatives thereof, mean inclusion without limitation; the term "or," is inclusive, meaning and/or; the phrases "associated with" and "associated therewith," as well as derivatives thereof, may mean to include, be included within, interconnect with, contain, be contained within, connect to or with, couple to or with, be communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound to or with, have, have a property of, or the like; and the term "controller" means any device, system or part thereof that controls at least one operation, such a device may be implemented in hardware, firmware or software, or some combination of at least two of the same. It should be noted that the functionality associated with any particular controller may be centralized or distributed, whether locally or remotely. Definitions for certain words and phrases are provided throughout this patent document, those of ordinary skill in the art should understand that in many, if not most instances, such definitions apply to prior, as well as future uses of such defined words and phrases.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure and its advantages, reference is now made to the following description taken in conjunction with the accompanying drawings, in which like reference numerals represent like parts:

FIG. **1** illustrates an external shape of a washing machine in accordance with one embodiment of the present disclosure;

FIG. **2** illustrates a bottom of the washing machine in accordance with one embodiment of the present disclosure;

FIG. **3** illustrates a clutch assembly included in the washing machine in accordance with one embodiment of the present disclosure;

FIG. **4** illustrates the exploded clutch assembly included in the washing machine in accordance with one embodiment of the present disclosure;

FIG. **5** illustrates a clutch boss and a clutch coupling of the clutch assembly included in the washing machine in accordance with one embodiment of the present disclosure;

FIG. **6** illustrates a configuration for controlling an operation of the washing machine in accordance with one embodiment of the present disclosure;

FIGS. **7**A and **7**B illustrate a speed detector included in the washing machine in accordance with one embodiment of the present disclosure;

FIG. **8** illustrates a motor driver included in the washing machine in accordance with one embodiment of the present disclosure;

FIGS. **9**A to **9**C illustrate an example in which the washing machine in accordance with one embodiment of the present disclosure operates or stops a driving motor based on an operation time of the driving motor;

FIGS. **10**A to **10**C are views illustrating that the washing machine in accordance with one embodiment of the present disclosure controls a rotary speed of a rotating tub;

FIG. **11** is a flowchart illustrating an example of a method in which washing machine controls the rotary speed of the rotating tub in accordance with one embodiment of the present disclosure;

FIG. **12** illustrates the rotary speed of the rotating tub when the driving motor is controlled according to the method shown in FIG. **11**;

FIGS. **13**A to **13**C are views illustrating that the washing machine in accordance with one embodiment of the present disclosure controls the rotary speed of the rotating tub;

FIG. **14** is a flowchart illustrating another example of the method of controlling the rotary speed of the rotating tub by the washing machine in accordance with one embodiment of the present disclosure;

FIG. **15** illustrates the rotary speed of the rotating tub when the driving motor is controlled according to the method shown in FIG. **14**;

FIG. **16** is a cross-sectional view illustrating the clutch boss and the clutch coupling of the clutch assembly included in the washing machine in accordance with one embodiment of the present disclosure;

FIGS. **17** and **18** are cross-sectional views illustrating the clutch boss and the clutch coupling when the washing machine in accordance with one embodiment of the present disclosure operates the driving motor;

FIG. **19** is a flowchart illustrating an example of a method of controlling torque of the driving motor by the washing machine in accordance with one embodiment of the present disclosure;

FIGS. **20**A to **20**C illustrate an example of a driving voltage supplied to the driving motor according to the method shown in FIG. **19**;

FIG. **21** is a flowchart illustrating another example of the method of controlling the torque of the driving motor by the washing machine in accordance with one embodiment of the present disclosure;

FIG. **22** is a flowchart illustrating an example of a method of detecting a failure of the speed detector by the washing machine in accordance with one embodiment of the present disclosure;

FIG. **23** is a flowchart illustrating another example of the method of detecting the failure of the speed detector by the washing machine in accordance with one embodiment of the present disclosure; and

FIGS. **24** to **29** illustrate a relationship between the omission of a position display member and a rotary speed detected by a speed sensor included in the washing machine in accordance with one embodiment of the present disclosure.

DETAILED DESCRIPTION

FIGS. **1** through **29**, discussed below, and the various embodiments used to describe the principles of the present disclosure in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the disclosure. Those skilled in the art will understand that the principles of the present disclosure may be implemented in any suitably arranged washing machine technologies. Hereinafter, one embodiment of the present disclosure will be described in detail with reference to the attached drawings.

FIG. **1** illustrates an external shape of a washing machine **1** in accordance with one embodiment of the present disclosure. FIG. **2** illustrates a bottom of the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIGS. **1** and **2**, the washing machine **1** includes a cabinet **10** which forms the external shape, a tub **20** which contains water, a rotating tub **30** rotatably disposed in the tub **20**, a pulsator **40** which generates a water current in the rotating tub **30**, a water supply unit **50** which supplies water, a detergent supply unit **60** which supplies a detergent, a drainage unit **70** which discharges water, a driving motor **80** which generates torque, a pulley unit **90** which transfers the torque of the driving motor **80** to a clutch assembly **100**, and the clutch assembly **100** which selectively transfers the torque to the rotating tub **30** and the pulsator **40**.

An inlet **11** is formed in a top of the cabinet **10** to allow laundry to be inserted into the rotating tub **30** and is opened and closed by a door **13** installed above the cabinet **10**.

The tub **20** can be formed in a cylindrical shape with an open top and can contain water for washing therein. Also, a drain **20***a* for discharging the water contained in the tub **20** can be provided at a bottom side of the tub **20**.

The tub **20** is supported by a damper **21** while being held by the cabinet **10**. The damper **21** damps vibrations which occur at the tub **20** while the rotating tub **30** or the pulsator **40** rotates and is provided between an external surface of the tub **20** and an internal surface of the cabinet **10**.

The rotating tub **30** can be formed in a cylindrical shape with an open top to allow the laundry to be inserted therein and is rotatably provided in the tub **20**.

The rotating tub **30** contains the laundry and water therein. A plurality of water-discharge holes **31** are formed in a lateral side of the rotating tub **30** to interconnect an internal space of the rotating tub **30** with an internal space of the tub **20**.

A balancer **33** which offsets an unbalanced load which occurs at the rotating tub **30** while the rotating tub **30** rotates is mounted on a top of the rotating tub **30** and allows the rotating tub **30** to stably rotate.

The pulsator **40** can be provided at a bottom inside the rotating tub **30** and generates the water current while rotating clockwise or counterclockwise. Due to the water current generated by the pulsator **40**, the laundry in the rotating tub **30** is stirred together with the water. Washing is performed by friction between the laundry and water.

The water supply unit **50** is provided above the tub **20** and supplies water into the tub **20** from an external water supply source (not shown).

The water supply unit **50** includes a water supply pipe **51** which guides the water to the tub **20** from the external water supply source and a water supply valve **53** provided on the water supply pipe **51** to open and close the water supply pipe **51**.

One end of the water supply pipe **51** is connected to the detergent supply unit **60** which will be described below. The water supplied through the water supply pipe **51** passes through the detergent supply unit **60** and is supplied to the tub **20**.

The detergent supply unit **60** includes a detergent box **63** which contains the detergent and a detergent box case **61** which accommodates the detergent box **63**.

The detergent box case **61** is provided to be fixed to the cabinet **10** and is connected to the one end of the water supply pipe **51** described above. Also, an outlet **61***a* for discharging the water which passes through the detergent supply unit **60** to the tub **20** is provided at a bottom side of the detergent box case **61**.

The detergent box **63** is detachably mounted in the detergent box case **61** in such a way that a user can withdraw the detergent box **63** from the detergent box case **61** to insert the detergent into the detergent box **63**.

The detergent box **63** is connected to the water supply pipe **51** to allow the water supplied through the water supply pipe **51** to be mixed with the detergent contained in the detergent box **63**. As described above, the water supplied by the water supply unit **50** is mixed with the detergent contained in the detergent box **63** while passing through the detergent box **63** and the water mixed with the detergent is supplied to the tub **20** through the outlet **61***a* provided at the bottom side of the detergent box case **61**.

The drainage unit **70** can be provided below the tub **20** and discharges the water contained in the tub **20** from the cabinet **10**.

The drainage unit **70** includes a first drainpipe **71** which guides the water contained in the tub **20** outward from the tub **20**, a drain valve **72** which opens and closes the first drainpipe **71**, a drainage motor **73** which drives the drain valve **72**, and a second drainpipe **74** which guides the water which passes through the drain valve **72** outward from the cabinet **10**.

One end of the first drainpipe **71** is connected to the drain **20***a* provided in the bottom side of the tub **20** and another end thereof is connected to the drain valve **72**.

The drain valve **72** is provided at the one side of the first drainpipe **71** and opens and closes the first drainpipe **71**. When the drain valve **72** is opened, the water in the tub **20** can be discharged outward through the first drainpipe **71** and the second drainpipe **74**.

The drain valve **72** can receive a driving force for opening and closing the drain valve **72** from the drainage motor **73**.

The drainage motor **73** drives opening and closing of the drain valve **72** through a link wire **73**a. In detail, when the drainage motor **73** is operated, the drain valve **72** can be opened and the water in the tub **20** can be discharged. When the drainage motor **73** is not operated, the drain valve **72** can be closed.

Also, the drainage motor **73** can switch an operation mode of the clutch assembly **100** through the link wire **73**a. As will be described below, the clutch assembly **100** can operate in a washing mode of transferring torque to the pulsator **40** and a spin-drying mode of transferring the torque to the rotating tub **30** and the pulsator **40**.

For example, the clutch assembly **100** can operate in the spin-drying mode when the drainage motor **73** is operated and can operate the clutch assembly **100** in the washing mode when the drainage motor **73** is not operated.

One end of the second drainpipe **74** is connected to the second drainpipe **74** and another end thereof extends from the cabinet **10** to guide the water discharged through the first drainpipe **71** to the outside of the cabinet **10**.

The driving motor **80** includes a motor housing **81** which forms an external shape, a stator **82** which generates a rotating magnetic field, a rotor **83** which rotates due to the rotating magnetic field, and a driving shaft **85** coupled with the rotor **83** to rotate together with the rotor **83**. The driving motor **80** generates torque which rotates the rotating tub **30** and the pulsator **40**.

The stator **82** can be fixed in the motor housing **81** and can have a cylindrical shape with a hollow. Also, the stator **82** includes a coil which generates the rotating magnetic field when being charged with electric current and the coil is disposed along an inner circumferential surface of the stator **82**.

The rotor **83** is rotatably provided in the stator **82** and rotates due to interaction with the rotating magnetic field generated by the stator **82**.

The driving shaft **84** is coupled with the rotor **83** to rotate together with the rotor **83** and transfers the torque of the rotor **83** to the pulley unit **90** which will be described below.

The driving motor **80** described above can employ an induction motor (IM) in which an induced current is generated at the rotor **83** due to the rotating magnetic field generated by the stator **82** and the rotor **83** rotates due to interaction between a magnetic field caused by the induced current and the rotating magnetic field generated by the stator **82**.

However, the driving motor **80** included in the washing machine **1** is not limited to the IM. For example, the driving motor **80** can employ a synchronous motor (SM) in which the rotor **83** includes a permanent magnet which generates a magnetic field.

Hereinafter, it is assumed that the driving motor **80** included in the washing machine **1** employs the IM.

The pulley unit **90** includes a driving pulley **91** which receives the torque from the driving motor **80**, a driven pulley **93** which transfers the torque to the clutch assembly **100**, and a pulley belt **92** which transfers the torque of the driving pulley **91** to the driven pulley **93**. Here, the driving pulley **91** is connected to the driving shaft **85** of the driving motor **80** and the driven pulley **93** is connected to a driven shaft **140** of the clutch assembly **100**.

To briefly describe a process of transferring the torque, the driving motor **80** generates the torque using alternating current (AC) power supplied from an external power supply and transfers the generated torque to the pulley unit **90**. Also, the pulley unit **90** transfers the torque transferred from the driving motor **80** to the clutch assembly **100** through the pulley belt **92**.

As described above, since the torque generated by the driving motor **80** is transferred to the clutch assembly **100** through the pulley unit **90**, a rotary speed of the driving motor **80** and a rotary speed of the clutch assembly **100** can differ from each other. For example, when a diameter of the driving pulley **91** connected to the driving motor **80** is smaller than a diameter of the driven pulley **93** connected to the clutch assembly **100**, the torque of the driving motor **80** can be transferred to the clutch assembly **100** while being reduced in speed by the pulley unit **90**.

The clutch assembly **100** selectively transfers the torque received from the pulley unit **90** to the rotating tub **30** and the pulsator **40**. In detail, the clutch assembly **100** transfers the torque received from the pulley unit **90** to the pulsator **40** while reducing the torque in speed in a washing operation or a rinsing operation and transfers the torque received from the pulley unit **90** to the rotating tub **30** and the pulsator **40** as it is in a spin-drying operation. Accordingly, in the spin-drying operation, the rotary speed of the clutch assembly **100** and the rotary speed of the rotating tub **30** are identical.

The clutch assembly **100** will be described below in more detail.

FIG. **3** illustrates the clutch assembly **100** included in the washing machine **1** in accordance with one embodiment of the present disclosure. FIG. **4** illustrates the exploded clutch assembly **100** included in the washing machine **1** in accordance with one embodiment of the present disclosure. FIG. **5** illustrates a clutch boss **180** and a clutch coupling **170** of the clutch assembly **100** included in the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIGS. **3** to **5**, a clutch housing **110** formed by coupling an upper housing **112** and a lower housing **111** forms an external shape of the clutch assembly **100**. In the clutch housing **110**, a washing shaft **145** and a spin-drying shaft **155** are installed to protrude above the clutch housing **110**.

The spin-drying shaft **155** can be formed of a cylindrical shaft with a hollow center and the washing shaft **145** can be inserted into a hollow of the spin-drying shaft **155**. The spin-drying shaft **155** and the washing shaft **145** are coupled to each other to be rotatable simultaneously or separately. The washing shaft **145** extends to further protrude upward than the spin-drying shaft **155** and is coupled with the pulsator **40**. The spin-drying shaft **155** is coupled with the rotating tub **30**. The washing shaft **145** allows the pulsator **40** to rotate. The spin-drying shaft **155** allows the rotating tub **30** to rotate.

A housing gear **151** can be formed at a bottom of the clutch housing **110** while protruding downward. The housing gear **151** can be connected to the spin-drying shaft **155** in the clutch housing **110**. That is, when the housing gear **151** rotates, the spin-drying shaft **155** and the rotating tub **30** connected to the spin-drying shaft **155** are allowed to rotate.

The housing gear **151** can be formed to be with a hollow center. The driven shaft **140** can be inserted into a hollow of the housing gear **151**. The driven shaft **140** is connected to the washing shaft **145** while penetrating the hollow of the housing gear **151**. Accordingly, when the driven shaft **140** rotates, the washing shaft **145** and the pulsator **40** connected to the washing shaft **145** are allowed to rotate.

The driven shaft **140** includes a shaft body **141** which has a rod shape and forms a body. A shaft gear **142** can be formed above the shaft body **141**. The shaft gear **142** can be coupled with a reduction gear (not shown) provided in the clutch housing **110**. The reduction gear can allow rotary speeds of the driven shaft **140** and the washing shaft **145** to be identical or to differ through controlling a gear ratio of the driven shaft **140** to the shaft gear **142**.

A boss coupling portion **143** for coupling with the clutch boss **180** can be formed below the shaft body **141**. The boss coupling portion **143** can be formed to have a polygonal cross section not a circular one to be strongly coupled with the clutch boss **180**. Depending on embodiments, a shape of the cross section of the boss coupling portion **143** can include a circle and other polygons.

A shaft bottom end **144** of the shaft body **141** is coupled with the driven pulley **93**. Accordingly, when the driving motor **80** rotates, the driven shaft **140** is allowed to rotate.

The clutch boss **180** is configured to include a boss body **181** and a shaft coupling hole **183** formed by opening a central portion of the boss body **181**. The shaft coupling hole **183** is formed in a shape corresponding to that of the boss coupling portion **143** of the shaft body **141** to allow the driven shaft **140** and the clutch boss **180** to be strongly coupled. Since the clutch boss **180** has to transfer torque of the driven shaft **140** which rotates due to the driven pulley **93** to the rotating tub **30** through the clutch coupling **170**, the housing gear **151**, and the spin-drying shaft **155**, it is necessary to be strongly coupled with the driven shaft **140**.

A plurality of boss protrusions **182** to be coupled with a plurality of coupling protrusions **173** of the clutch coupling **170** are formed above the boss body **181**.

The clutch coupling **170** is disposed between a bottom side of the clutch housing **110** and the clutch boss **180**.

The clutch coupling **170** is configured to be coupled with the clutch boss **180**, to receive torque through the driven shaft **140** and the clutch boss **180**, and to transfer the torque to the housing gear **151**, the spin-drying shaft **155**, and the rotating tub **30**.

The clutch coupling **170** includes a shaft through hole **172** formed by perforating a central portion thereof to allow a body of the driven shaft **140** to penetrate therethrough. A coupling tooth form **171** is formed on an inner side of the shaft through hole **172** to be engaged with and fixed to the housing gear **151**.

A mounting portion **175** is formed while protruding along a circumference of the central portion of the clutch coupling **170** from a radial direction. A coupling elastic member **176** is mounted on a top side of the mounting portion **175**, and a coupling lever **130** is in contact with a bottom side of the mounting portion **175**.

The plurality of coupling protrusions **173** are formed below the clutch coupling **170** while protruding inward in the radial direction. A plurality of coupling grooves **174** are each formed among the plurality of coupling protrusions **173**. The coupling protrusions **173** are formed to allow the coupling grooves **174** to be formed in a shape corresponding to that of the boss protrusions **182** of the clutch boss **180**.

The clutch coupling **170** is disposed below the clutch housing **110** to allow the coupling tooth form **171** to be coupled with the housing gear **151**. The driven shaft **140** penetrates the shaft through hole **172** and is coupled with the clutch boss **180** below the clutch coupling **170**.

As the coupling tooth form **171** slides along sawteeth of the housing gear **151**, the clutch coupling **170** is disposed to be vertically movable.

When the clutch coupling **170** descends, the boss protrusions **182** of the clutch boss **180** are inserted into the coupling grooves **174**, thereby coupling the clutch coupling **170** with the clutch boss **180**. Accordingly, when the driven shaft **140** rotates, the clutch boss **180** fixed to the driven shaft **140** rotates and the clutch coupling **170** also rotates according thereto. When the clutch coupling **170** rotates, the housing gear **151** coupled through the coupling tooth form **171** rotates and the spin-drying shaft **155** and the rotating tub **30** rotate according thereto. In other words, the clutch assembly **100** operates in the spin-drying mode.

When the clutch coupling **170** ascends, the clutch boss **180** and the clutch coupling **170** are separated from each other and disconnected. Accordingly, the clutch coupling **170** does not rotate and also the housing gear **151**, the spin-drying shaft **155**, and the rotating tub **30** do not rotate. In other words, the clutch assembly **100** operates in the washing mode.

The coupling lever **130** includes a lever top portion **131** and a lever bottom portion **132**. The lever top portion **131** and the lever bottom portion **132** are formed to have a certain angle therebetween based on first rotation center holes **136**.

A coupling guide **133** is formed while protruding forward from a bottom end of the lever bottom portion **132**. The coupling guide **133** can be formed while being divided into two from the bottom end of the lever bottom portion **132**. The two coupling guides **133** can be formed in an annular shape with one open side.

A first contact protrusion **134** is formed at an end of each of the coupling guides **133** while protruding upward. The first contact protrusion **134** is in contact with the bottom side of the mounting portion **175** of the clutch coupling **170**.

A first stopper **135** can be formed while protruding forward from a top end of the lever top portion **131**. The first stopper **135** is in contact with a housing side to limit pivoting of the coupling lever **130**.

The coupling lever **130** is pivotally installed on a lever holder **160**. The lever holder **160** is mounted on a bottom side of the lower housing **111**. An annular holder plate **161** forms an external shape of the lever holder **160**.

Two first mounting portions **164** spaced apart at a certain interval from the holder plate **161** are provided. First mounting holes **165** are formed in the first mounting portions **164**. The coupling lever **130** is coupled with the lever holder **160** to dispose the first rotation center holes **136** between the two first mounting portions **164**. A first elastic member **137** is disposed between the two first rotation center holes **136**. A first coupling pin **138** penetrates the first mounting holes **165**, the first rotation center holes **136**, and the first elastic member **137** to couple the coupling lever **130** with the lever holder **160**.

The coupling lever **130** pivots on the first rotation center holes **136** to allow the coupling guides **133** to ascend and descend. Also, the coupling guides **133** of the coupling lever **130** are in contact with the clutch coupling **170** to allow the clutch coupling **170** to vertically move.

The first elastic member **137** pressurizes the coupling lever **130** due to elasticity thereof to allow the coupling guides **133** of the coupling lever **130** to descend.

A plurality of coupling holes **163** can be formed in the holder plate **161** while penetrating the holder plate **161**. As a fastening member (not shown) penetrates the coupling holes **163** and is inserted into the lower housing **111**, the lever holder **160** can be coupled with the clutch housing **110**.

A clutch lever **120** is mounted on the housing side to be pivotable along a horizontal direction based on a second rotation center hole **126** formed in an end of a lever body **121**. Two second mounting portions **111**_a_ are formed on the housing side while being spaced apart at a certain interval to install the clutch lever **120**. Second mounting holes **111***b* are formed in the second mounting portions **111***a*. The clutch lever **120** is mounted on the second mounting portions **111***a* to dispose the second rotation center hole **126** between the two second mounting portions **111***a*. A second elastic member **127** is disposed between the second rotation center holes **126** and one of the second mounting holes **111***b*. A second coupling pin **128** penetrates the second mounting holes **111***b*, the second rotation center hole **126**, and the second elastic member **127** to couple the clutch lever **120** with the clutch housing **110**.

A lever guide **123** and a second stopper **122** can be formed at the end of the lever body **121**. The lever guide **123** and the second stopper **122** are diverged from the end of the lever body **121** to be in mutually opposite directions based on the second rotation center hole **126**.

The lever guide **123** and the second stopper **122** are formed to be adjacent to the housing side while the second stopper **122** is bent toward the housing side.

The lever guide **123** is in contact with or separated from the lever top portion **131** of the coupling lever **130**. Particularly, a side of the lever guide **123** opposite a side adjacent to the housing side is in contact with or separated from the lever top portion **131**. A second contact protrusion **124** protrudes from a part of the lever guide **123**, adjacent to the lever top portion **131**.

In the lever body **121**, a connection portion **125** to which the drainage motor **73** for driving the clutch lever **120** is connected is formed at an end opposite the part at which the lever guide **123** and the second stopper **122** are formed.

The clutch lever **120** is configured to be pivotable in the horizontal direction based on the second rotation center hole **126**. The second elastic member **127** pressurizes the clutch lever **120** in a direction in which the second stopper **122** is located. Accordingly, when an external force is not applied, a state in which the second stopper **122** is in contact with the housing side is maintained.

When the clutch lever **120** pivots in the direction in which the second stopper **122** is located, the lever guide **123** pushes the lever top portion **131** of the coupling lever **130** aside. When the lever top portion **131** is pushed aside, the coupling guides **133** ascend and the clutch coupling **170** ascends. Due to ascending of the clutch coupling **170**, the clutch coupling **170** and the clutch boss **180** are separated. In other words, the clutch assembly **100** operates in the washing mode.

Here, due to elastic forces of the first elastic member **137** and the coupling elastic member **176**, the clutch coupling **170** and the coupling guides **133** are pressurized downward. The clutch coupling **170** and the coupling guides **133** can ascend when receiving a force greater than the elastic forces. Accordingly, an elastic force of the second elastic member **127** can be greater than a sum of the elastic force of the first elastic member **137** and the elastic force of the coupling elastic member **176**.

On the other hand, when the clutch lever **120** overcomes the elastic force of the second elastic member **127** and pivots in a direction in which the lever guide **123** extends due to the drainage motor **73**, the lever guide **123** does not push the lever top portion **131** any more and is separated from the lever top portion **131**.

When an external force applied to the coupling lever **130** is removed, due to the elastic forces of the second elastic member **127** and the coupling elastic member **176**, the coupling lever **130** pivots to allow the coupling guides **133** to descend and the clutch coupling **170** also descends. When the clutch coupling **170** descends, the clutch coupling **170** is coupled with the clutch boss **180** in such a way that the clutch boss **180** and the clutch coupling **170** rotate at the same time. In other words, the clutch assembly **100** operates in the spin-drying mode.

As described above, the clutch assembly **100** can operate in the washing mode of transferring the torque to the pulsator **40** and in the spin-drying mode of transferring the torque to the pulsator **40** and the rotating tub **30** depending on whether the drainage motor **73** operates.

FIG. **6** illustrates a configuration for controlling an operation of the washing machine **1** in accordance with one embodiment of the present disclosure. FIGS. **7**A and **7**B illustrate a speed detector **230** included in the washing machine **1** in accordance with one embodiment of the present disclosure. FIG. **8** illustrates a motor driver **240** included in the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIGS. **6** to **8**, the washing machine **1** includes a user interface **220** which interacts with a user, the speed detector **230** which detects the rotary speed of the rotating tub **30** or the pulsator **40**, the motor driver **240** which drives the driving motor **80**, and a controller **210** which controls operations of various components included in the washing machine **1**, in addition to the cabinet **10**, the tub **20**, the rotating tub **30**, the pulsator **40**, the water supply unit **50**, the detergent supply unit **60**, the drainage unit **70**, the driving motor **80**, the pulley unit **90**, and the clutch assembly **100** described above.

Since the water supply valve **53** and the drainage motor **73** shown in FIG. **6** have been described above, a description thereof will be omitted.

The user interface **220** can include an input button unit **221** and a display **223**.

The input button unit **221** receives various setting values related to washing and control commands related to the washing machine **1** from the user and outputs electric signals corresponding to the setting value and the control command input by the user to the controller **210**.

For example, the input button unit **221** can include a plurality of operation buttons which receive the control command with respect to the washing machine **1** and a dial which receives settings for a washing operation. The washing machine **1** can receive a washing mode from the user through the dial and can receive additional washing settings such as a washing temperature, a number of times of washing, a number of times of rinsing, and a level of spin-drying through the operation buttons. The operation buttons described above can employ push switches, membrane switches, or a touch pad.

The display **223** can display operation information of the washing machine **1** to the user as visual images according to a control signal of the controller **210**.

For example, before the washing operation, the washing machine **1** can display the washing mode selected by the user, the additional washing settings input by the user such as the washing temperature, the number of times of rinsing, the level of spin-drying, etc., and an estimated washing time until washing is completed through the display **223**. Also, during the washing operation, the washing machine **1** can display information on an operation in progress, for example, whether the operation is the washing operation, the rinsing operation, or the spin-drying operation, a residual washing time left until the washing is completed, etc. through the display **223**.

The display **223** described above can employ one of a light emitting diode (LED) panel, a liquid crystal display (LCD) panel, and an organic LED (OLED) panel.

Also, the user interface **220** can include a touch screen in which an input means and a display means are integrated.

A touch screen panel displays setting values or control commands selectable by the user through the display **223**. When the user selects and touches any one of the setting values and the control commands displayed on the touch screen panel, the touch screen panel can detect coordinates of the touch of the user and compares the detected coordinates of the touch with coordinates on which the setting value or the control command is displayed, thereby recognizing the setting value or the control command input by the user.

The speed detector **230** includes a position indicating member **231** and a speed sensor **233**.

The position indicating member **231** is installed in the driving motor **80** or the clutch assembly **100** and indicates rotation of the driving motor **80** or the clutch assembly **100**. The speed sensor **233** senses the position indicating member **231** and outputs an electric signal corresponding to whether the position indicating member **231** is sensed, to the controller **210**. Also, the controller **210** can determine the rotary speed of the rotating tub **30** based on the electric signal output from the speed sensor **233**.

For example, the speed sensor **233** can output "a high signal" when the position indicating member **231** is sensed and can output "a low signal" when the position indicating member **231** is not sensed. When the driving motor **80** or the clutch assembly **100** rotates, the speed sensor **233** can regularly detect the position indicating member **231** and can output the electric signal in a pulse form.

The controller **210** can analyze an electric pulse output from the speed sensor **233** to calculate a frequency or period of the electric pulse and can determine the rotary speed of the rotating tub **30** based on the calculated frequency or period of the electric pulse.

The position indicating member **231** can be located in a rotating component such as the driving shaft **85** and the driven shaft **140**. Also, the speed sensor **233** can be located in a fixed component such as the motor housing **81** and the clutch housing **110**.

For example, the position indicating member **231** can be provided in the clutch boss **180** which rotates at the same rotary speed as that of the driven shaft **140**. In detail, as shown in FIG. 7A, one or more position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* can be disposed at equidistant intervals along an outer circumferential surface of the clutch boss **180**. Here, the number of position indicating members **231** is six in FIG. **7** but is not limited thereto.

When the position indicating member **231** is provided in the clutch boss **180** of the clutch assembly **100**, the speed sensor **233** can be provided in a position adjacent to the clutch boss **180**. In detail, the speed sensor **233**, as shown in FIG. 7B, can be supported by a sensor supporter **233***a* to be installed adjacent to the outer circumferential surface of the clutch boss **180**. Here, the sensor supporter **233***a* can extend downward from the bottom side of the clutch housing **110** toward the driven pulley **93**.

As described above, the speed sensor **233** is installed adjacent to the clutch boss **180** in which a plurality of such position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* are installed, thereby allowing the speed sensor **233** to regularly sense the position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* while the clutch boss **180** rotates.

However, positions of the position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* are not limited to the clutch boss **180** but can be various.

For example, the position indicating member **231** can be provided in the driven pulley **93** coupled with the driven shaft **140** and the speed sensor **233** can be provided below the clutch housing **110**. The position indicating member **231** can rotate together with the driven pulley **93**. The speed sensor **233** can regularly detect the position indicating member **231** while the position indicating member **231** rotates.

As another example, the position indicating member **231** can be provided on an external surface of the reduction gear provided in the clutch housing **110** and the speed sensor **233** can be provided on one side of the clutch housing **110**. The position indicating member **231** can rotate together with the reduction gear. The speed sensor **233** can regularly detect the position indicating member **231** while the position indicating member **231** rotates.

As still another example, the position indicating member **231** can be provided in the driving pulley **91** coupled with the driving shaft **115** and the speed sensor **233** can be provided below the motor housing **81**. The position indicating member **231** can rotate together with the driving pulley **91**. The speed sensor **233** can regularly detect the position indicating member **231** while the position indicating member **231** rotates.

The position indicating member **231** and the speed sensor **233** can employ various components which detect rotational displacement or a rotary speed of a rotor, respectively.

For example, the position indicating member **231** can include a permanent magnet which generates a magnetic field, a reflecting plate which reflects light, and a protrusion which protrudes toward the speed sensor **233**. Also, the speed sensor **233** can include a hall sensor or a magnetoresistive (MR) sensor which detects a magnetic field depending on the position indicating member **231**, an infrared sensor which transmits light and detects the light reflected by the reflecting plate, and a micro switch pressurized by the protrusion.

In detail, when the position indicating member **231** includes the permanent magnet, the speed sensor **233** can include the hall sensor or the MR sensor. When the position indicating member **231** includes the reflecting plate, the speed sensor **233** can include the infrared sensor. When the position indicating member **231** includes the protrusion, the speed sensor **233** can include the micro switch.

Hereinafter, for understanding, it will be described while it is assumed that the position indicating member **231** includes the permanent magnet and the speed sensor **233** includes the hall sensor or the MR sensor.

The motor driver **240** includes a driving switch unit **241** which supplies power to the driving motor **80** or cuts off the power supplied to the driving motor **80** depending on a driving signal of the controller **210** which will be described below.

The driving switch unit **241**, as shown in FIG. **8**, can be connected to an external power supply PS and the driving motor **80** in series. Also, when the driving switch unit **241** is turned on, the power is supplied to the driving motor **80** to drive the driving motor **80**. When the driving switch unit **241** is turned off, the power supplied to the driving motor **80** is cut off to stop the driving motor **80**.

As described above, the washing machine **1** supplies or cuts off the power to the driving motor **80** to control the rotary speed of the driving motor **80** but does not control a level or frequency of a driving voltage supplied to the driving motor **80**.

The driving switch unit **241** can include a high voltage switch which conducts or cuts off the power supplied to the driving motor **80** from the external power supply PS depending on the driving signal output from the controller **210**. For example, the driving switch unit **241** can include a relay, a photo-coupler, a thyristor, a triac, a power bipolar junction transistor (BJT), a power metal-oxide-semiconductor field effect transistor (MOSFET), a static induction transistor (SIT), an insulated gate bipolar transistor (IGBT), etc.

The driving switch unit **241**, in addition to the high voltage switch described above, can further include a zero-crossing detector which detects a point in time when a voltage and current of AC power input from the external power supply PS become "0" and a porter coupler which isolates the controller **210** formed of a low voltage device for the external power supply PS and the driving motor **80** to which a high voltage is supplied or cut off.

The controller **210** can include a memory **213** which stores a program and data for controlling the washing machine **1** and a processor **211** which processes the data according to the program stored in the memory **213**.

The memory **213** can store a control program and control data for controlling the washing machine **1** or can store setting values and control commands input through the user interface **220**, a rotary speed input from the speed detector **230**, and control signals output by the processor **211**.

The memory **213** can include a volatile memory (not shown) such as a static random access memory (S-RAM) and a dynamic random access memory (D-RAM) and a nonvolatile memory (not shown) such as a flash memory, a read only memory (ROM), and an erasable programmable read only memory (EPROM), and an electrically EPROM (EEPROM).

The nonvolatile memory can operate as an auxiliary memory for the volatile memory and can store the control program and control data for controlling the operation of the washing machine **1**. The nonvolatile memory can keep stored data even though power of the washing machine **1** is cut off.

The volatile memory can load and temporarily store the control program and control data for controlling the washing machine **1** or can temporarily store the setting values and control commands input through the user interface **220**, the rotary speed input from the speed detector **230**, and the control signals output by the processor **211**. The volatile memory, unlike the nonvolatile memory, can lose stored data when the power of the washing machine **1** is cut off.

The processor **211** can process the setting values, control commands, and rotary speed according to the control programs and control data stored in the memory **213** and can output a driving signal for controlling the driving motor **80** and the control signals for controlling the water supply valve **53** and the drainage motor **73**.

For example, the processor **211** can determine a washing time, a number of times of rinsing, and a spin-drying time according to the setting values and control commands input by the user. During the washing operation and rinsing operation, the processor **211** can output a control signal of opening the water supply valve **53**, a driving signal of rotating the driving motor **80** clockwise or counterclockwise, and a control signal for operating the drainage motor **73**. Also, during the spin-drying operation, the processor **211** can output the control signal of operating the drainage motor **73** and a driving signal of operating or stopping the driving motor **80** depending on the rotary speed of the clutch assembly **100** detected by the speed detector **230**.

In the above, the processor **211** and the memory **213** have been separately described but are not limited thereto and can be formed as a single chip.

As described above, the controller **210** can control the operations of all kinds of the components included in the washing machine **1**. Also, it will be understood that the operation of the washing machine **1** which will be described below can be performed according to a control operation of the controller **210**.

As described above, the components of the washing machine **1** have been described.

Hereinafter, the operation of the washing machine **1**, and more particularly, the spin-drying operation will be described.

The user can select a washing mode through the user interface **220** and can input detailed setting values such as a washing temperature, a number of times of rinsing, and a level of spin-drying depending on each washing mode. After that, when the user inputs an operation start command through the user interface **220**, the washing machine **1** can perform a series of operations which will be described below.

First, the washing machine **1** can detect an amount of laundry to determine an amount of water to be supplied to the tub **20** during the washing operation or the rinsing operation.

For example, the washing machine **1** can operate the driving motor **80** for a predetermined time and can detect an amount of laundry contained in the rotating tub **30** based on changes in a driving current supplied to the driving motor **80** and in the rotary speed of the clutch assembly **100**. In other words, the washing machine **1** can calculate the amount of the laundry using a fact in which the rotary speed of the clutch assembly **100** becomes smaller as the amount of the laundry contained in the rotating tub **30** becomes larger. After that, the washing machine **1** can determine the amount of water to be supplied to the tub **20** during the washing operation or rinsing operation depending on the detected amount of the laundry.

Additionally, the washing machine **1** may not calculate the amount of the laundry and can directly determine the amount of the water to be supplied to the tub **20** based on the changes in the driving current supplied to the driving motor **80** and in the rotary speed of the clutch assembly **100**.

As another example, the washing machine **1** can include a weight sensor which senses a weight in the damper **21** supporting the tub **20** and can detect the amount of the laundry contained in the rotating tub **30** based on an output of the weight sensor.

After that, the washing machine **1** performs the washing operation.

The washing operation includes water supply of supplying water to the tub **20**, washing of washing laundry by rotating the pulsator **40**, drainage of discharging the water from the tub **30**, and intermediate spin-drying of separating the water from the laundry by rotating the rotating tub **30**.

During the water supply, the washing machine **1** opens the water supply valve **53** and supplies the water and a detergent to the tub **20**.

During the washing, the washing machine **1** generates a water current which rotates in the rotating tub **30** by alternately rotating the pulsator **40** clockwise and counterclockwise. Due to the water current which rotates described above, the laundry in the rotating tub **30** is washed. Particularly, the washing machine **1** can transfer the torque of the driving motor **80** to the pulsator **40** by switching the clutch assembly **100** into the washing mode.

During the drainage, the washing machine **1** opens the drain valve **72** by operating the drainage motor **73**. Also, the clutch assembly **100** is switched into the spin-drying mode by operating of the drainage motor **73**.

During the intermediate spin-drying, the washing machine **1** operates the driving motor **80** to rotate the rotating tub **30**. Here, the operating of the drainage motor **73** is maintained to allow the clutch assembly **100** to maintain the spin-drying mode. As described above, since the clutch assembly **100** operates in the spin-drying mode, the torque of the driving motor **80** can be transferred to both the rotating tub **30** and the pulsator **40**.

After that, the washing machine **1** performs the rinsing operation.

The rinsing operation includes water supply of supplying water to the tub **20**, rinsing of rinsing laundry by rotating the pulsator **40**, drainage of discharging the water from the tub **30**, and intermediate spin-drying of separating the water from the laundry by rotating the rotating tub **30**.

During the rinsing, the washing machine **1** generates a water current which rotates in the rotating tub **30** by alternately rotating the pulsator **40** clockwise and counterclockwise. Due to the water current which rotates described above, the laundry in the rotating tub **30** is rinsed. The water supply, drainage, and intermediate spin-drying are identical to those of the washing operation described above.

After that, the washing machine **1** performs the spin-drying operation. During the spin-drying operation, the washing machine **1** maintains the clutch assembly **100** in the spin-drying mode to allow the torque of the driving motor **80** to be transferred to both the rotating tub **30** and the pulsator **40**.

The spin-drying operation includes intermittent spin-drying of gradually increasing a rotary speed of the rotating tub **30** and main spin-drying of rotating the rotating tub **30** at a high speed. Not only the spin-drying operation but also the intermediate spin-drying of the washing operation and the intermediate spin-drying of the rinsing operation can include the intermittent spin-drying and the main spin-drying.

The intermittent spin-drying and the main spin-drying will be described below in detail.

In the above, the operation of the washing machine **1** includes the washing operation, the rinsing operation, and the spin-drying operation but is not limited thereto. For example, the washing machine **1** can perform some of the washing operation, the rinsing operation, and the spin-drying operation depending on a selection of the user. In detail, the user can operate the washing machine to perform only the washing machine **1** for rough washing or can operate the washing machine **1** to perform only the spin-drying operation after hand-washing.

As described above, the spin-drying operation includes the intermittent spin-drying and the main spin-drying.

During the intermittent spin-drying, the washing machine **1** gradually increases the rotary speed of the rotating tub **30** to discharge the water separated from the laundry. During the main spin-drying, the washing machine **1** maintains the rotary speed of the rotating tub **30** at a maximum rotary speed. When the rotary speed of the rotating tub **30** is rapidly increased, the water separated from the laundry is not yet discharged and collected at the bottom of the tub **20**. As described above, the water collected at the bottom of the tub **20** interrupts rotation of the rotating tub **30** to increase a load on the driving motor **80**.

When the load on the driving motor **80** increases to a certain level or more, an operation of the driving motor **80** stops. As described above, to prevent the load on the driving motor **80** from being rapidly increased, the washing machine **1** performs the intermittent spin-drying of gradually increasing the rotary speed of the rotating tub **30**.

The washing machine **1** repetitively performs operating and stopping the operating of the driving motor **80** using an AC motor to gradually increase the rotary speed of the rotating tub **30**.

The washing machine **1** can determine whether to operate the driving motor **80** or to stop an operation thereof based on various conditions. For example, the washing machine **1** can determine a point in time of operating the driving motor **80** and a point in time of stopping the operating of the driving motor **80** based on the amount of the laundry.

Also, to determine the point in time of operating the driving motor **80** and the point in time of stopping the operating of the driving motor **80**, a resonance phenomenon which occurs while the rotating tub **30** rotates can be considered.

The rotary speed of the rotating tub **30** in the spin-drying operation, particularly, in the intermittent spin-drying passes at least one resonance speed.

A resonance is a phenomenon in which vibration of the tub **20** extremely increases due to the rotation of the rotating tub **30**. The vibration of the tub **20** is amplified at a certain rotary speed. When the resonance phenomenon occurs, vibration of the washing machine **1** and noise caused by the vibration extremely increase and the washing machine **1** can be damaged in severe cases.

The resonance caused by the rotation of the rotating tub **30** can be generally divided into two types. Although a difference is present depending on a size of the rotating tub **30**, there are present a first resonance which occurs when the rotary speed of the rotating tub **30** is about 100 rpm and a second resonance which occurs when the rotary speed of the rotating tub **30** is about 300 rpm. During the first resonance, the whole tub **20** which accommodates the rotating tub **30** extremely vibrates left and right. Also, during the second resonance, a top and a bottom of the tub **20** which accommodates the rotating tub **30** vibrate in mutually opposite directions.

The first resonance and second resonance described above do not occur only at a certain rotary speed can occur at a sequential rotary speed range. Hereinafter, a rotary speed area in which the first resonance occurs will be referred to a first resonance area R**1** and a rotary speed area in which the second resonance occurs will be referred to as a second resonance area R**2**.

The vibration caused by the resonance phenomenon described above can be minimized by reducing a number in which the rotary speed of the rotating tub **30** passes a resonance area or increasing a weight of the tub **20** which accommodates the rotating tub **30**.

As described above, to reduce a time in which the rotary speed of the rotating tub **30** passes the resonance area or the number in which the rotary speed of the rotating tub **30** passes the resonance area, the operating of the driving motor **80** and the stopping the operating of the driving motor **80** can be repetitively performed.

For example, the washing machine **1** can operate the driving motor **80** for a time previously determined based on an operation time of the driving motor **80** and can stop the operating of the driving motor **80** for a predetermined time.

FIGS. **9**A to **9**C illustrate an example in which the washing machine **1** in accordance with one embodiment of the present disclosure operates or stops the operating of the driving motor **80** based on the operation time of the driving motor **80**.

As shown in FIG. **9**, the washing machine **1** can repetitively operate the driving motor **80** for a predetermined turn-on time Ton and stop the operating of the driving motor **80** for a turn-off time Toff.

In detail, the controller **210** of the washing machine **1** can transmit a driving signal shown in FIG. **9**A to the motor driver **240**. That is, the controller **210** repetitively turns on the driving switch unit **241** for the turn-on time T_{on} and turns off the driving switch unit **241** for the turn-off time T_{off}.

Due to the driving signal shown in FIG. **9**A, a driving voltage shown in FIG. **9**B is supplied to the driving motor **80**. That is, the power of the external power supply PS is supplied to the driving motor **80** during a time in which the driving switch unit **241** is turned on and is cut off during a time in which the driving switch unit **241** is turned off.

As a result thereof, as shown in FIG. **9**C, the rotary speed of the rotating tub **30** varies. That is, the rotary speed of the rotating tub **30** increases during the time in which the driving switch unit **241** is turned on and decreases during the time in which the driving switch unit **241** is turned off.

The turn-on time Ton and the turn-off time T_{off} of the driving switch unit **241** are appropriately set, thereby allowing the rotary speed of the rotating tub **30** to once pass the first resonance area R**1** and the second resonance area R**2** as shown in a first speed graph SG**1** in FIG. **9**C.

However, when an amount of laundry increases or a power supply which supplies electric energy to a driving motor is unstable, as shown in a second speed graph SG**2** in FIG. **9**C, a rotary speed of a rotating tub can pass the first resonance area R**1** and the second resonance area R**2** several times. As a result, vibration of the rotating tub can extremely increase during an intermittent spin-drying operation.

As another example, a target speed is preset and the washing machine **1** can operate the driving motor **80** to allow the rotary speed of the rotating tub **30** to get to the target speed. Here, the target speed can be preset by a designer for the washing machine **1** and stored in the memory **213** of the controller **210**.

In detail, the washing machine **1** can compare the rotary speed detected by the speed detector **230** with the target speed and can control power supplied to the driving motor **80** according to a result of the comparison.

The washing machine **1** can use various methods for controlling the power supplied to the driving motor **80**. The washing machine **1** can control a phase angle of the power supplied to the driving motor **80** or can intermittently supply the power to the driving motor **80**.

Controlling of the phase angle of the power supplied to the driving motor **80** is generally referred to as "phase angle control". Intermittently supplying of the power to the driving motor **80** is generally referred to as "hysteresis control".

First, it will be described that the washing machine **1** controls the rotary speed of the rotating tub **30** through "phase angle control".

FIGS. **10**A to **10**C are views illustrating that the washing machine **1** in accordance with one embodiment of the present disclosure controls the rotary speed of the rotating tub **30**.

The external power supply PS supplies an input voltage Vin to the washing machine **1** as shown in FIG. **10**A. Here, the input voltage Vin input from the external power supply PS can be AC voltage which has a frequency of 50 Hz or 60 Hz and a voltage of 110 V or 220 V.

The controller **210** of the washing machine **1** can detect a point in time when the voltage of the input voltage Vin becomes "0" (hereinafter, referred to as "zero crossing ZC") using the zero crossing detector.

When the zero crossing ZC is detected, the controller **210** turns off the driving switch unit **241** of the motor driver **240** for the turn-off time T_{off} from the zero crossing ZC as shown in FIG. **10**B. Here, the turn-off time Toff can be set as a time shorter than one half cycle of the input voltage Vin and can vary according to the rotary speed of the rotating tub **30**. When the rotary speed of the rotating tub **30** exceeds the target speed, the turn-off time T_{off} increases. When the rotary speed of the rotating tub **30** is less than the target speed, the turn-off time T_{off} is reduced.

When the driving switch unit **241** is turned off, as shown in FIG. **10**C, a driving voltage Vout is not supplied to the driving motor **80**.

When the turn-off time T_{off} passes from the zero crossing ZC, the controller **210** turns on the driving switch unit **241**.

When the driving switch unit **241** is turned on, as shown in FIG. **10**C, the driving voltage Vout is supplied to the driving motor **80**. Here, due to inductance of the driving motor **80**, the driving voltage Vout has a sine wave form.

After that, when the zero crossing ZC is detected again, the controller **210** turns off the driving switch unit **241** of the motor driver **240** as shown in FIG. **10**B. When the driving switch unit **241** is turned off, as shown in FIG. **10**C, the supplying of the driving voltage Vout to the driving motor **80** is stopped again.

According to "the phase angle control" described above, only a part of input power supplied from the external power supply PS is transferred to the driving motor **80** and the rotary speed of the driving motor **80** varies according to driving power supplied to the driving motor **80**.

Here, the controller **210** can control the rotary speed of the driving motor **80** by adjusting the turn-off time Toff. In detail, when the controller **210** increases the turn-off time Toff, the driving power supplied to the driving motor **80** is reduced and the rotary speed of the driving motor **80** is reduced. Also, when the controller **210** reduces the turn-off time T_{off}, the driving power supplied to the driving motor **80** increases and the rotary speed of the driving motor **80** increases.

Also, since the frequency of the input voltage Vin is preset, the controller **210** can control the rotary speed of the driving motor **80** by adjusting a duty ratio which indicates a ratio of the turn-on time Ton of turning on the driving switch unit **241** to one half cycle Tcycle of the input voltage Vin.

The adjusting of the turn-off time T_{off} by the controller **210** has the same meaning as the adjusting of a duty ratio of the driving signal by the controller **210**. When the controller **210** increases the turn-off time T_{off}, the duty ratio of the driving signal is reduced. When the controller **210** reduces the turn-off time T_{off}, the duty ratio of the driving signal increases.

Also, the increasing of the duty ratio of the driving signal by the controller **210** means the reducing of the turn-off time T_{off} by the controller **210**. The reducing of the duty ratio of the driving signal by the controller **210** means the increasing of the turn-off time T_{off} by the controller **210**.

Hereinafter, a method in which the washing machine **1** controls the rotary speed of the rotating tub **30** using "phase angle control" will be described in detail.

FIG. **11** is a flowchart illustrating an example of the method in which the washing machine **1** controls the rotary speed of the rotating tub **30** in accordance with one embodiment of the present disclosure. FIG. **12** illustrates the rotary speed of the rotating tub **30** when the driving motor **80** is controlled according to the method shown in FIG. **11**.

Referring to FIGS. **11** and **12**, a method **1100** in which the washing machine **1** controls the rotary speed of the rotating tub **30** during the spin-drying operation will be described.

When the spin-drying operation begins, the washing machine operates the driving motor **80** (S**1110**).

Here, the washing machine **1** maintains the clutch assembly **100** in the spin-drying mode to allow the torque of the driving motor **80** to be supplied to the rotating tub **30** and the pulsator **40**. In other words, during the intermittent spin-drying, the controller **210** operates the drainage motor **73**.

Also, the controller **210** turns on the driving switch unit **241** of the motor driver **240** to allow the power of the external power supply PS to be supplied to the driving motor **80**. When the driving switch unit **241** is turned on, the power of the external power supply PS is supplied to the driving motor **80** and the driving motor **80** rotates.

The washing machine **1** sets the target speed of the rotating tub **30** (S**1120**).

As described above, the target speed of the rotating tub **30** can be preset by the designer for the washing machine **1** and stored in the memory **213** of the controller **210**.

Here, the target speed can vary as the spin-drying operation has been performed. For example, as shown in FIG. **12**, the target speed can increase to a first target speed S**1** between a point in time of beginning of the spin-drying operation and a first point in time T**1** and can be maintained at the first target speed S**1** from the point in time T**1** to a second point in time T**2**. Also, the target speed can increase to a second target speed S**2** between the second point in time T**2** and a third point in time T**3** and can be maintained at the second target speed S**2** between the third point in time T**3** and a fourth point in time T**4**. Also, the target speed can increase to a third target speed S**3** between the third point in time T**3** and the fourth point in time T**4** and can be maintained at the third target speed S**3** after the fourth point in time T**4**.

The controller **210** can set the target speed by loading a target speed corresponding to a time in which the spin-drying operation is performed from the memory **213**.

The washing machine **1** detects the rotary speed of the rotating tub **30** (S**1130**).

The controller **210** of the washing machine **1** detects rotary speeds of the clutch assembly **100** and the rotating tub **30** based on an electric signal output by the speed detector **230**.

As described above, in the spin-drying mode of the clutch assembly **100**, the clutch assembly **100** transfers the torque provided from the driving motor **80** to the rotating tub **30** and the pulsator **40** as it is. Accordingly, the controller **210** can detect the rotary speed of the clutch assembly **100** using the speed detector **230** to detect the rotary speed of the rotating tub **30**.

Also, due to a difference between the diameters of the driving pulley **91** and the driven pulley **93**, the rotary speed of the driving motor **80** and the rotary speed of the clutch assembly **100** can differ from each other. In other words, the controller **210** can calculate the rotary speeds of the clutch assembly **100** and the rotating tub **30** using a ratio of the diameter of the driving pulley **91** to the diameter of the driven pulley **93** and the rotary speed of the driving motor **80**. Accordingly, the controller **210** can detect the rotary speed of the driving motor **80** to detect the rotary speed of the rotating tub **30**.

The washing machine **1** determines whether the rotary speed of the rotating tub **30** is less than the target speed (S**1140**).

The controller **210** of the washing machine **1** can compare the rotary speed of the rotating tub **30** with the target speed set in S**1120** and can determine whether the rotary speed of the rotating tub **30** is smaller than the target speed.

When the rotary speed of the rotating tub **30** is determined to be less than the target speed (Yes in S**1140**), the washing machine **1** increases the duty ratio of the driving signal (S**1150**).

When the rotary speed of the rotating tub **30** is less than the target speed, the controller **210** of the washing machine **1** increases the power supplied to the driving motor **80** to increase the rotary speed of the rotating tub **30**. In detail, the controller **210** can reduce the turn-off time Toff in which the driving switch unit **241** is turned off and can increase the turn-on time Ton in which the driving switch unit **241** is turned on.

In other words, the controller **210** can increase a turn-on time duty ratio of the driving signal for controlling the motor driver **240**.

The washing machine **1** determines whether the spin-drying operation is finished (S**1180**).

In detail, the controller **210** of the washing machine **1** can compare a time in which the spin-drying operation is performed with a spin-drying time input by the user and can finish the spin-drying operation when the time in which the spin-drying operation is performed is greater than the spin-drying time.

When the spin-drying operation is determined to be finished (Yes in S**1180**), the washing machine **1** stops the operation. When the spin-drying operation is not determined to be finished (No in S**1180**), the washing machine **1** resets the target speed depending on the time of performing the spin-drying operation (S**1120**).

Also, when the rotary speed of the rotating tub **30** is determined to be not less than the target speed (No in S**1140**), the washing machine **1** determines whether the rotary speed of the rotating tub **30** exceeds the target speed (S**1160**).

The controller **210** of the washing machine **1** can compare the rotary speed of the rotating tub **30** with the target speed set in S**1120** and can determine whether the rotary speed of the rotating tub **30** is greater than the target speed.

When the rotary speed of the rotating tub **30** is determined to be more than the target speed (Yes in S**1160**), the washing machine **1** reduces the duty ratio of the driving signal (S**1170**).

When the rotary speed of the rotating tub **30** exceeds the target speed, the controller **210** of the washing machine **1** reduces the power supplied to the driving motor **80** to reduce the rotary speed of the rotating tub **30**. In detail, the controller **210** can increase the turn-off time Toff in which the driving switch unit **241** is turned off and can reduce the turn-on time Ton in which the driving switch unit **241** is turned on.

In other words, the controller **210** can reduce the turn-on time duty ratio of the driving signal for controlling the motor driver **240**.

The washing machine **1** determines whether the spin-drying operation is finished (S**1180**). After that, the operation of the washing machine **1** is the same as described above.

When the rotary speed of the rotating tub **30** is not determined to be more than the target speed (No in S**1160**), the washing machine **1** determines whether the spin-drying operation is finished (S**1180**).

When the rotary speed of the rotating tub **30** is not greater or smaller than the target speed, the controller **210** can determine the rotary speed of the rotating tub **30** to be identical to the target speed. Accordingly, the controller **210** does not change the duty ratio of the driving signal.

According to the phase angle control method **1100** in the washing machine **1** described above, the rotary speed of the rotating tub **30** can vary as shown in FIG. **12**. In other words, the rotary speed of the rotating tub **30** can gradually arrive at the target speed while fluctuating.

Particularly, when the first target speed **51** is set as a rotary speed between the first resonance area R**1** and the second resonance area R**2** and the second target speed S**2** is set to be greater than the second resonance area R**2**, the rotary speed of the rotating tub **30** passes the first resonance area R**1** and the second resonance area R**2** once as shown in FIG. **12**.

Next, it will be described that the washing machine **1** controls the rotary speed of the rotating tub **30** using "hysteresis control".

FIGS. **13**A to **13**C are views illustrating that the washing machine **1** in accordance with one embodiment of the present disclosure controls the rotary speed of the rotating tub **30**.

The external power supply PS supplies an input voltage Vin to the washing machine **1** as shown in FIG. **13**A. Here, the input voltage Vin input from the external power supply PS can be AC voltage which has a frequency of 50 Hz or 60 Hz and a voltage of 110 V or 220 V.

The controller **210** of the washing machine **1** can determine whether the rotary speed detected by the speed detector **230** is within a certain speed range and can operate the driving motor **80** or stop the operating of the driving motor **80** when the rotary speed is out of the certain speed range. Here, the certain speed range can be set based on the target speed.

In detail, when the rotary speed of the rotating tub **30** is greater than the certain speed range, the controller **210** turns off the driving switch unit **241** of the motor driver **240** to stop the operating of the driving motor **80**. Also, when the rotary speed of the rotating tub **30** is smaller than the certain speed range, the controller **210** turns on the driving switch unit **241** to operate the driving motor **80**.

Particularly, a driving signal of turning on or turning off the driving switch unit **241**, as shown in FIG. **12**B, can be synchronized with a point in time when the voltage of the input voltage Vin becomes "0" (hereinafter, referred to as "zero crossing"). In other words, when the zero crossing is detected, the controller **210** can switch the driving signal from ON to OFF or can switch the driving signal from OFF to ON.

As described above, when the driving signal is switched using the zero crossing, it is possible to lighten a burden on the driving switch unit **241** to cut off a high voltage input from the external power supply PS.

According to the driving signal shown in FIG. **13**B, a driving voltage Vout shown in FIG. **13**C is supplied to the driving motor **80**.

According to "the hysteresis control" described above, supplying the power and cutting off the power from the external power supply PS to the driving motor **80** are repetitively performed. Depending on the supplying of the power and the cutting off the power, the rotary speed of the driving motor **80** varies.

Hereinafter, a method in which the washing machine **1** controls the rotary speed of the rotating tub **30** using "hysteresis control" will be described in detail.

FIG. **14** is a flowchart illustrating another example of the method of controlling the rotary speed of the rotating tub **30** by the washing machine **1** in accordance with one embodiment of the present disclosure. FIG. **15** illustrates the rotary speed of the rotating tub **30** when the driving motor **80** is controlled according to the method shown in FIG. **14**.

Referring to FIGS. **14** and **15**, a method **1200** in which the washing machine **1** controls the rotary speed of the rotating tub **30** during the spin-drying operation will be described.

When the spin-drying operation begins, the washing machine **1** operates the driving motor **80** (S**1210**).

Here, the washing machine **1** maintains the clutch assembly **100** in a spin-drying mode to allow the torque of the driving motor **80** to be supplied to the rotating tub **30** and the pulsator **40**. In other words, during the intermittent spin-drying, the controller **210** operates the drainage motor **73**.

Also, the controller **210** turns on the driving switch unit **241** of the motor driver **240** to allow the power of the external power supply PS to be supplied to the driving motor **80**. When the driving switch unit **241** is turned on, the power of the external power supply PS is supplied to the driving motor **80** and the driving motor **80** rotates.

The washing machine **1** sets the target speed of the rotating tub **30** (S**1220**).

As described above, the target speed of the rotating tub **30** can be preset by the designer for the washing machine **1** and stored in the memory **213** of the controller **210**.

Here, the target speed can vary as the spin-drying operation has been performed. For example, as shown in FIG. **15**, the target speed can increase to a first target speed S**1** between a point in time of beginning of the spin-drying operation and a first point in time T**1** and can be maintained at the first target speed S**1** from the point in time T**1** to a second point in time T**2**. Also, the target speed can increase to a second target speed S**2** between the second point in time T**2** and a third point in time T**3** and can be maintained at the second target speed S**2** between the third point in time T**3** and a fourth point in time T**4**. Also, the target speed can increase to a third target speed S**3** between the third point in time T**3** and the fourth point in time T**4** and can be maintained at the third target speed S**3** after the fourth point in time T**4**.

The controller **210** can set the target speed by loading a target speed corresponding to a time in which the spin-drying operation is performed from the memory **213**.

The washing machine **1** detects the rotary speed of the rotating tub **30** (S**1230**).

The controller **210** of the washing machine **1** detects rotary speeds of the clutch assembly **100** and the rotating tub **30** based on an electric signal output by the speed detector **230**.

As described above, in the spin-drying mode of the clutch assembly **100**, the clutch assembly **100** transfers the torque provided from the driving motor **80** to the rotating tub **30** and the pulsator **40** as it is. Accordingly, the controller **210** can detect the rotary speed of the clutch assembly **100** to detect the rotary speed of the rotating tub **30**.

Also, due to the difference between the diameters of the driving pulley **91** and the driven pulley **93**, the rotary speed of the driving motor **80** and the rotary speed of the clutch assembly **100** can differ from each other. In other words, the controller **210** can calculate the rotary speeds of the clutch assembly **100** and the rotating tub **30** using the ratio of the diameter of the driving pulley **91** to the diameter of the driven pulley **93** and the rotary speed of the driving motor **80**. Accordingly, the controller **210** can detect the rotary speed of the driving motor **80** to detect the rotary speed of the rotating tub **30**.

The washing machine **1** determines whether the driving motor **80** is operating (S**1240**).

The controller **210** of the washing machine **1** can determine whether the driving motor **80** is operating using various methods.

For example, it is possible to determine whether the driving motor **80** is operating, based on the driving signal output to the motor driver **240**. In detail, when the driving signal is an ON signal for turning on the driving switch unit **241**, the controller **210** can determine the driving motor **80** as operating. Also, when the driving signal is an OFF signal for turning off the driving switch unit **241**, the controller **210** can determine the operating of the driving motor **80** as being stopped.

As another example, the controller **210** can store operation information of the driving motor **80** when operating the driving motor **80** or stopping the operating of the driving motor **80** in the memory **213** in the controller **210** and can determine whether the driving motor **80** is operating, based on the operation information stored in the memory **213**.

In detail, the controller **210** can store the operating of the driving motor **80** in the memory **213** when the driving motor **80** is operated and can store the stopping the operating of the driving motor **80** in the memory **213** when the operating of the driving motor **80** is stopped. After that, the controller **210** can determine that the driving motor **80** is operating when the operating of the driving motor **80** is stored in the memory **213** and can determine that the operating of the driving motor **80** is stopped when the stopping the operating of the driving motor **80** is stored in the memory **213**.

When the driving motor **80** is operating (Yes in S**1240**), the washing machine **1** determines whether the rotary speed of the rotating tub **30** is greater than a sum of the target speed and an allowable error (S**1250**).

The controller **210** of the washing machine **1** can compare the rotary speed of the rotating tub **30** with the sum of the target speed and the allowable error set in S**1220** and can determine whether the rotary speed of the rotating tub **30** is greater than the sum of the target speed and the allowable error. Here, the allowable error can be set by considering the target speed and vibration caused by operating or stopping the driving motor **80**.

When the rotary speed of the rotating tub **30** is determined to be more than the sum of the target speed and the allowable error (Yes in S**1250**), the washing machine **1** stops the operating of the driving motor **80** (S**1260**).

The controller **210** cuts off the power supplied to the driving motor **80** to reduce the rotary speed of the rotating tub **30**. In detail, the controller **210** can output the driving signal for turning off the driving switch unit **241**.

The washing machine **1** determines whether the spin-drying operation is finished (S**1290**).

In detail, the controller **210** of the washing machine **1** can compare a time in which the spin-drying operation is performed with a spin-drying time input by the user and can finish the spin-drying operation when the time in which the spin-drying operation is performed is greater than the spin-drying time.

When the spin-drying operation is determined to be finished (Yes in S**1290**), the washing machine **1** stops the operation. When the spin-drying operation is not determined to be finished (No in S**1290**), the washing machine **1** resets the target speed depending on the time in which the spin-drying operation is performed (S**1220**).

Also, when the rotary speed of the rotating tub **30** is not determined to be more than the sum of the target speed and the allowable error (No in S**1250**), the washing machine **1** determines whether the spin-drying operation is finished (S**1290**). After that, the operation of the washing machine **1** is identical as described above.

When the driving motor **80** is not operating (No in S**1240**), the washing machine **1** determines whether the rotary speed of the rotating tub **30** is smaller than a difference between the target speed and the allowable error (S**1270**).

The controller **210** of the washing machine **1** can compare the rotary speed of the rotating tub **30** with the difference between the target speed set in S**1220** and the allowable error and can determine whether the rotary speed of the rotating tub **30** is smaller than the difference between the target speed and the allowable error. Here, the allowable error can be set by considering the target speed and vibration caused by operating or stopping the driving motor **80**.

When the rotary speed of the rotating tub **30** is determined to be smaller than the difference between the target speed and the allowable error (Yes in S**1270**), the washing machine **1** operates the driving motor **80** (S**1280**).

The controller **210** supplies the power to the driving motor **80** to increase the rotary speed of the rotating tub **30**. In detail, the controller **210** can output the driving signal for turning on the driving switch unit **241**.

The washing machine **1** determines whether the spin-drying operation is finished (S**1290**). After that, the operation of the washing machine **1** is the same as described above.

Also, when the rotary speed of the rotating tub **30** is not determined to be smaller than the difference between the target speed and the allowable error (No in S**1270**), the washing machine **1** determines whether the spin-drying operation is finished (S**1290**). After that, the operation of the washing machine **1** is the same as described above.

According to the hysteresis control method **1200** in the washing machine **1** described above, the rotary speed of the rotating tub **30** can vary as shown in FIG. **15**. In other words, the rotary speed of the rotating tub **30** fluctuates around the target speed.

As described above, the method in which the washing machine **1** controls the rotary speed of the rotating tub **30** during the spin-drying operation has been described.

Hereinafter, a method of reducing noise caused by the clutch assembly **100** and abrasion of the clutch assembly **100** during the spin-drying operation will be described.

FIG. **16** is a cross-sectional view illustrating the clutch boss **180** and the clutch coupling **170** of the clutch assembly **100** included in the washing machine **1** in accordance with one embodiment of the present disclosure. FIGS. **17** and **18** are cross-sectional views illustrating the clutch boss **180** and the clutch coupling **170** when the washing machine **1** in accordance with one embodiment of the present disclosure operates the driving motor **80**.

When the clutch assembly **100** operates in the spin-drying mode, as shown in FIG. **16**, the boss protrusions **182** of the clutch boss **180** are inserted into the coupling grooves **174** of the clutch coupling **170**, thereby coupling the clutch boss **180** with the clutch coupling **170**. For example, as shown in an enlarged part in FIG. **16**, a first boss protrusion **182*a*** is inserted into a first coupling groove **174*a*** formed between first coupling protrusion **173*a*** and a second coupling protrusion **173*b***.

To allow the clutch boss **180** and the clutch coupling **170** to be smoothly coupled with each other, widths of the coupling grooves **174** are greater than widths of the boss protrusions **182**. As a result, gaps are present between the boss protrusions **182** and the coupling protrusions **173**. For example, as shown in the enlarged part in FIG. **16**, a first gap D**1** is present between the first boss protrusion **182***a* and the first coupling protrusion **173***a* and a second gap D**2** is present between the first boss protrusion **182***a* and the second coupling protrusion **173***b*. The gaps D1 and D2 described above cause abrasions of the boss protrusions **182** and coupling protrusions **173** and noise.

When the driving motor **80** is not operated and the clutch assembly **100** does not rotate, for example, before the spin-drying operation is performed, the boss protrusions **182** and the coupling protrusions **173** maintain certain intervals therebetween.

Here, when the driving motor **80** is operated, due to the torque transferred from the driving motor **80**, the boss protrusions **182** apply impacts to the coupling protrusions **173**. For example, as shown in FIG. **17**, when counterclockwise torque is transferred to the clutch boss **180**, the first boss protrusion **182***a* applies an impact to the first coupling protrusion **173***a* due to the torque, noise occurs due to collision between the first boss protrusion **182***a* and the first coupling protrusion **173***a*, and the first boss protrusion **182***a* and the first coupling protrusion **173***a* wear and tear.

Also, when the driving motor **80** is not operated and the clutch assembly **100** rotates, for example, the operating of the driving motor **80** is stopped while the rotating tub **30** rotates during the spin-drying operation, the boss protrusions **182** are in contact with the coupling protrusions **173** in a direction opposite to the rotation and maintain certain intervals from the coupling protrusions **173** in a rotation direction. For example, when the rotating tub **30** rotates counterclockwise, as shown in FIG. **18**, the first boss protrusion **182***a* is in contact with the second coupling protrusion **173***b* and maintains a certain interval from the coupling protrusion **173***a*.

Here, when the driving motor **80** is operated, due to the torque transferred from the driving motor **80**, the boss protrusions **182** apply impacts to the coupling protrusions **173**. For example, as shown in FIG. **18**, when counterclockwise torque is transferred to the clutch boss **180**, the first boss protrusion **182***a* applies an impact to the first coupling protrusion **173***a* due to the torque, noise occurs due to collision between the first boss protrusion **182***a* and the first coupling protrusion **173***a*, and the first boss protrusion **182***a* and the first coupling protrusion **173***a* wear and tear.

As described above, not only when the rotation of the rotating tub **30** begins during the spin-drying operation but also whenever the driving motor **80** repetitively operates and stops while the rotating tub **30** rotates, the boss protrusions **182** and the coupling protrusions **173** collide with each other.

To minimize the impact when the boss protrusions **182** and the coupling protrusions **173** collide with each other, the washing machine **1** can gradually increase the torque of the driving motor **80** when beginning the operating of the driving motor **80**.

FIG. **19** is a flowchart illustrating an example of a method of controlling the torque of the driving motor **80** by the washing machine **1** in accordance with one embodiment of the present disclosure. FIGS. **20**A to **20**C illustrate an example of a driving voltage supplied to the driving motor **80** according to the method shown in FIG. **19**.

Referring to FIGS. **19** to **20**C, the washing machine **1** determines whether to operate the driving motor **80** (S**1310**).

The controller **210** of the washing machine **1** can operate the driving motor **80** in various cases.

For example, when the spin-drying operation of the washing machine **1**, which includes the intermittent spin-drying, begins, the controller **210** can operate the driving motor **80**. Also, when the rotary speed of the rotating tub **30** is smaller than the difference between the target speed and the allowable error during the spin-drying operation, the controller **210** can operate the driving motor **80**.

In other words, the controller **210** can operate the driving motor **80** not only to begin the rotating of the rotating tub **30** but also to maintain the rotary speed of the rotating tub **30**.

When it is not determined to operate the driving motor **80** (No in S**1310**), the washing machine **1** continues an existing operation.

Also, when it is determined to operate the driving motor **80** (Yes in S**1310**), the washing machine **1** performs the phase angle control with a first duty ratio on the power supplied to the driving motor **80** (S**1320**).

As described above, "the phase angle control" is controlling a phase angle of the power supplied to the driving motor **80**. In other words, according to "the phase angle control", the washing machine **1** supplies only the part of the power supplied from the external power supply PS to the driving motor **80**.

Here, the first duty ratio can be set as various values.

For example, the first duty ratio can be set as 0.2 (20%). When the first duty ratio is set as 0.2, as shown in a first cycle in FIG. **20**, the controller **210** can output a driving signal with a duty ratio of 0.2 to the motor driver **240**. As a result, a driving voltage shown in the first cycle in FIG. **20** is supplied to the driving motor **80** and power of about 20% of input power supplied from the external power supply PS is supplied to the driving motor **80**.

After that, the washing machine **1** performs the phase angle control with a second duty ratio on the power supplied to the driving motor **80** (S**1330**).

Here, the second duty ratio can be set as a greater value than the first duty ratio.

For example, the second duty ratio can be set as 0.4 (40%). When the second duty ratio is set as 0.4, as shown in a second cycle in FIG. **20**, the controller **210** can output a driving signal with a duty ratio of 0.4 to the motor driver **240**. As a result, a driving voltage shown in the second cycle in FIG. **20** is supplied to the driving motor **80** and power of about 40% of the input power supplied from the external power supply PS is supplied to the driving motor **80**.

After that, the washing machine **1** performs the phase angle control with a third duty ratio on the power supplied to the driving motor **80** (S**1340**).

Here, the third duty ratio can be set as a greater value than the first duty ratio and the second duty ratio.

For example, the third duty ratio can be set as 0.6 (60%). When the third duty ratio is set as 0.6, as shown in a third cycle in FIG. **20**, the controller **210** can output a driving signal with a duty ratio of 0.6 to the motor driver **240**. As a result, a driving voltage shown in the third cycle in FIG. **20** is supplied to the driving motor **80** and power of about 60% of the input power supplied from the external power supply PS is supplied to the driving motor **80**.

After that, the washing machine **1** performs the phase angle control with a fourth duty ratio on the power supplied to the driving motor **80** (S**1350**).

Here, the fourth duty ratio can be set as a greater value than the first duty ratio, the second duty ratio, and the third duty ratio.

For example, the fourth duty ratio can be set as 0.8 (80%). When the fourth duty ratio is set as 0.8, as shown in a fourth cycle in FIG. **20**, the controller **210** can output a driving signal with a duty ratio of 0.8 to the motor driver **240**. As a result, a driving voltage shown in the fourth cycle in FIG. **20** is supplied to the driving motor **80** and power of about 80% of the input power supplied from the external power supply PS is supplied to the driving motor **80**.

After that, the washing machine **1** supplies the whole power supplied from the external power supply PS to the driving motor **80** (S**1360**).

The controller **210** of the washing machine **1** can output a driving signal with 1 (100%) to the motor driver **240**. As a result, as shown in a fifth cycle in FIG. **20**, a driving voltage identical to an input voltage is supplied to the driving motor **80**.

However, the method of controlling the torque of the driving motor **80** is not limited to the method described above.

FIG. **21** is a flowchart illustrating another example of the method of controlling the torque of the driving motor **80** by the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIG. **21**, the washing machine **1** determines whether to operate the driving motor **80** (S**1410**).

The controller **210** of the washing machine **1** can operate the driving motor **80** in various cases.

For example, when the spin-drying operation of the washing machine **1**, which includes the intermittent spin-drying, begins, the controller **210** can operate the driving motor **80**. Also, when the rotary speed of the rotating tub **30** is smaller than the difference between the target speed and the allowable error during the spin-drying operation, the controller **210** can operate the driving motor **80**.

In other words, the controller **210** can operate the driving motor **80** not only to begin the rotating of the rotating tub **30** but also to maintain the rotary speed of the rotating tub **30**.

When it is not determined to operate the driving motor **80** (No in S**1410**), the washing machine **1** continues an existing operation.

Also, when it is determined to operate the driving motor **80** (Yes in S**1410**), the washing machine **1** initializes a duty ratio (S**1420**).

The controller **210** of the washing machine **1** can input an initial value 에 the duty ratio. Here, the initial value can be "0".

After that, the washing machine **1** performs the phase angle control (S**1430**).

The controller **210** of the washing machine **1** performs the phase angle control on the power supplied to the driving motor **80** based on the duty ratio previously set.

As described above, "the phase angle control" is controlling the phase angle of the power supplied to the driving motor **80**. In other words, according to "the phase angle control", the washing machine **1** supplies only the part of the power supplied from the external power supply PS to the driving motor **80**.

After that, the washing machine **1** determines whether the duty ratio is "1 (100%)" or more (S**1450**).

The controller **210** of the washing machine **1** can determine whether the duty ratio is "1 (100%)" or more by comparing the duty ratio previously set with "1".

When the duty ratio is not "1 (100%)" or more (No in S**1450**), the washing machine **1** increases the duty ratio.

Since the driving motor **80** of the washing machine **1** is not fully operated when the duty ratio is not "1 (100%)" or more, the controller **210** of the washing machine **1** increases the duty ratio by a predetermined value. For example, the controller **210** can increase the duty ratio by 0.2 (20%).

After that, the washing machine **1** performs the phase angle control again.

Also, when the duty ratio is "1 (100%)" or more (Yes in S**1450**), the washing machine **1** fully operates the driving motor **80**.

The controller **210** of the washing machine **1** supplies the whole power supplied from the external power supply PS to the driving motor **80**. In detail, the controller **210** can output a driving signal with the duty ratio of 1 (100%) to the motor driver **240**.

As described above, when beginning the operating of the driving motor **80**, the washing machine **1** can perform "the phase angle control" to gradually increase the torque output by the driving motor **80**. As a result, the torque of the driving motor **80** gradually increases in such a way that the abrasion and noise caused by the impact between the boss protrusions **182** of the clutch boss **180** and the coupling protrusions **173** of the clutch coupling **170** are reduced.

In detail, when "the phase angle control" is not performed, noise of about 59.68 dB and vibration of 114.83 m/s2 occur from the clutch assembly **100**. However, when "the phase angle control" is performed, noise of about 55.65 dB and vibration of 26.01 m/s2 occur from the clutch assembly **100**.

As described above, the speed detector **230** performs a significant role to control the rotary speed of the rotating tub **30** during the spin-drying operation of the washing machine **1**.

Hereinafter, a method of detecting a failure of the speed detector **230** will be described.

FIG. **22** is a flowchart illustrating an example of the method of detecting the failure of the speed detector **230** by the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIG. **22**, the washing machine **1** determines whether to operate the driving motor **80** (S**1510**).

The controller **210** of the washing machine **1** can operate the driving motor **80** in various cases.

For example, when the spin-drying operation of the washing machine **1**, which includes the intermittent spin-drying, begins, the controller **210** can operate the driving motor **80**. Also, when the rotary speed of the rotating tub **30** is smaller than the difference between the target speed and the allowable error during the spin-drying operation, the controller **210** can operate the driving motor **80**.

When it is not determined to operate the driving motor **80** (No in S**1510**), the washing machine **1** continues an existing operation.

Also, when it is determined to operate the driving motor **80** (Yes in S**1510**), the washing machine **1** determines whether a reference time passes after the operating of the driving motor **80** (S**1520**).

The controller **210** of the washing machine **1** can count a time which passes after the operating of the driving motor **80** and can compare the time which passes after the operating of the driving motor **80** with the reference time.

When it is not determined that the reference time passes after the operating of the driving motor **80** (No in S**1520**), the washing machine **1** continues the operating of the driving motor **80**.

Also, when it is determined that the reference time passes after the operating of the driving motor **80** (Yes in S**1520**), the washing machine **1** detects the rotary speed of the rotating tub **30** (S**1530**).

The controller **210** of the washing machine **1** detects rotary speeds of the clutch assembly **100** and the rotating tub **30** based on an electric signal output by the speed detector **230**.

As described above, in the spin-drying mode of the clutch assembly **100**, the clutch assembly **100** transfers the torque provided from the driving motor **80** to the rotating tub **30** and the pulsator **40** as it is. Accordingly, the controller **210** can detect the rotary speed of the clutch assembly **100** using the speed detector **230** to detect the rotary speed of the rotating tub **30**.

After that, the washing machine **1** determines whether the rotary speed of the rotating tub **30** is "0" (S**1540**).

The controller **210** of the washing machine **1** can detect the rotary speed of the rotating tub **30** based on the electric signal output by the speed detector **230** and can compare the detected rotary speed with "0".

When the rotary speed of the rotating tub **30** is not "0" (No in S**1540**), the washing machine **1** determines as a normal operation.

Also, when the rotary speed of the rotating tub **30** is "0" (Yes in S**1540**), the washing machine **1** displays a failure of the speed sensor **233** (S**1550**).

After operating the driving motor **80**, when it is not determined that the rotating tub **30** rotates, the controller **210** of the washing machine **1** can determine as a failure of the driving motor **80** or the speed detector **230**.

Here, since the washing machine **1** includes an additional protection circuit for detecting the failure of the driving motor **80**, when the rotating of the rotating tub **30** is not detected, the controller **210** can determine as the failure of the speed sensor **233**.

Accordingly, the controller **210** displays the failure of the speed sensor **233** to the user through the user interface **220**.

As described above, when the rotating of the rotating tub **30** is not detected after operating the driving motor **80**, the washing machine **1** can determine the failure of the speed sensor **233**.

FIG. **23** is a flowchart illustrating another example of the method of detecting the failure of the speed detector **230** by the washing machine **1** in accordance with one embodiment of the present disclosure.

Referring to FIG. **23**, the washing machine **1** fully operates the driving motor **80** (S**1610**).

To fully operate the driving motor **80**, the controller **210** of the washing machine **1** can supply the whole power supplied from the external power supply PS to the driving motor **80**. In detail, the controller **210** can output the driving signal for turning on the driving switch unit **241** to the motor driver **240**.

After that, the washing machine **1** determines whether a reference time passes after the operating of the driving motor **80** (S**1620**).

The controller **210** of the washing machine **1** can count a time which passes after the operating of the driving motor **80** and can compare the time which passes after the operating of the driving motor **80** with the reference time.

When it is not determined that the reference time passes after the operating of the driving motor **80** (No in S**1620**), the washing machine **1** continues the operating of the driving motor **80**.

Also, when it is determined that the reference time passes after the operating of the driving motor **80** (Yes in S**1620**), the washing machine **1** detects the rotary speed of the rotating tub **30** (S**1630**).

The controller **210** of the washing machine **1** detects rotary speeds of the clutch assembly **100** and the rotating tub **30** based on an electric signal output by the speed detector **230**.

As described above, in the spin-drying mode of the clutch assembly **100**, the clutch assembly **100** transfers the torque provided from the driving motor **80** to the rotating tub **30** and the pulsator **40** as it is. Accordingly, the controller **210** can detect the rotary speed of the clutch assembly **100** using the speed detector **230** to detect the rotary speed of the rotating tub **30**.

After that, the washing machine **1** determines whether the rotary speed of the rotating tub **30** is smaller than a reference speed (S**1640**).

The controller **210** of the washing machine **1** can detect the rotary speed of the rotating tub **30** based on the electric signal output by the speed detector **230** and can compare the detected rotary speed with the reference speed.

Here, the reference speed can be set as a rotary speed smaller than a maximum rotary speed of the rotating tub **30**. For example, when the maximum rotary speed of the rotating tub **30** is about 710 rpm, the reference speed can be set as about 650 rpm.

When the rotary speed of the rotating tub **30** is not smaller than the reference speed (No in S**1640**), the washing machine **1** determines as a normal operation.

Also, when the rotary speed of the rotating tub **30** is smaller than the reference speed (Yes in S**1640**), the washing machine **1** displays the omission of position indicating member **231** (S**1650**).

When the rotary speed of the rotating tub **30** is smaller than the reference speed even though the driving motor **80** is fully operated, the controller **210** can determine as the omission of the position indicating member **231**.

In addition, the controller **210** can determine the number of the omitted position indicating members **231** depending on the rotary speed of the rotating tub **30**. The determining of the number of the omitted position indicating members **231** depending on the rotary speed of the rotating tub **30** will be described below in detail.

As described above, when the rotating of the rotating tub **30** does not arrive at the reference speed after fully operating the driving motor **80**, the washing machine **1** can determine the omission of the position indicating member **231**.

FIGS. **24** to **29** illustrate a relationship between the omission of the position indicating members **231** and the rotary speed detected by the speed sensor **233** included in the washing machine **1** in accordance with one embodiment of the present disclosure.

As described above, the washing machine **1** can determine the number of the omitted position indicating members **231** depending on the rotary speed of the rotating tub **30**.

The rotary speed of the rotating tub **30** can vary according to various factors. For example, the rotary speed of the rotating tub **30** can vary according to a level and a frequency of an input voltage supplied to the driving motor **80** and an amount of laundry contained in the rotating tub **30**.

Hereinafter, for understanding, it is assumed that a voltage of 60 Hz and 120 V is supplied from the external power supply PS and the input voltage supplied from the external power supply PS has an error of about 15%. Also, it is assumed that the rotating tub **30** contains a load of 500 g. It is also assumed that the speed detector **230** includes the six position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* described above as shown in FIG. **7**A.

Referring to FIG. **24**, when all the six position indicating members **231***a*, **231***b*, **231***c*, **231***d*, **231***e*, and **231***f* are attached, a maximum rotary speed detected by the speed detector **230** is about 710 rpm. According to an experiment, the maximum rotary speed of the rotating tub **30** is about 694 rpm when the input voltage is 103 V and is about 717 rpm when the input voltage is 138 V.

Referring to FIG. **25**, when one position indicating member **231***a* is omitted, a maximum rotary speed detected by the speed detector **230** is about 605 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 598 rpm when the input voltage is 103 V and is about 610 rpm when the input voltage is 138 V.

When the two position indicating members **231** are omitted, a maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can vary according to positions of the omitted position indicating members **231**.

Referring to FIG. **26**, when the adjacent position indicating members **231***a* and **231***b* are omitted, a maximum rotary speed detected by the speed detector **230** is about 510 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 493 rpm when the input voltage is 103 V and is about 524 rpm when the input voltage is 138 V.

Also, when the position indicating members **231***a* and **231***c* located on both sides of one position indicating member **231***b* are omitted, a maximum rotary speed detected by the speed detector **230** is about 502 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 493 rpm when the input voltage is 103 V and is about 513 rpm when the input voltage is 138 V.

Also, when the position indicating members **231***a* and **231***d* which face each other are omitted, a maximum rotary speed detected by the speed detector **230** is about 490 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 481 rpm when the input voltage is 103 V and is about 498 rpm when the input voltage is 138 V.

As described above, when the two position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can be about 490 rpm to 510 rpm depending on the positions of the omitted position indicating members **231**.

When the three position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can vary according to positions of the omitted position indicating members **231**.

Referring to FIG. **27**, when the three adjacent position indicating members **231***a*, **231***b*, and **231***c* are omitted, a maximum rotary speed detected by the speed detector **230** is about 400 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 390 rpm when the input voltage is 103 V and is about 411 rpm when the input voltage is 138 V.

Also, when the adjacent position indicating members **231***a* and **231***b* and the position indicating member **231***d* not adjacent thereto are omitted, a maximum rotary speed detected by the speed detector **230** is about 390 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 383 rpm when the input voltage is 103 V and is about 395 rpm when the input voltage is 138 V.

Also, when the three position indicating members **231***a*, **231***c*, and **231***e*, which are not adjacent to one another, are omitted, a maximum rotary speed detected by the speed detector **230** is about 350 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 346 rpm when the input voltage is 103 V and is about 357 rpm when the input voltage is 138 V.

As described above, when the three position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can be about 350 rpm to 400 rpm depending on the positions of the omitted position indicating members **231**.

When the four position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can vary according to positions of the omitted position indicating members **231**.

Referring to FIG. **28**, when the four adjacent position indicating members **231***a*, **231***b*, **231***c*, and **231***d* are omitted, a maximum rotary speed detected by the speed detector **230** is about 280 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 277 rpm when the input voltage is 103 V and is about 282 rpm when the input voltage is 138 V.

Also, when the three adjacent position indicating members **231***a*, **231***b*, and **231***c* and the position indicating member **231***d* not adjacent thereto are omitted, a maximum rotary speed detected by the speed detector **230** is about 390 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 251 rpm when the input voltage is 103 V and is about 260 rpm when the input voltage is 138 V.

Also, when two pair of the position indicating members **231***a* and **231***b* and **231***d* and **231***e* which face one another, are omitted, a maximum rotary speed detected by the speed detector **230** is about 235 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 229 rpm when the input voltage is 103 V and is about 238 rpm when the input voltage is 138 V.

As described above, when the four position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, can be about 235 rpm to 280 rpm depending on the positions of the omitted position indicating members **231**.

Referring to FIG. **29**, when the five position indicating members **231***a*, **231***b*, **231***c*, **231***d*, and **231***e* are omitted, a maximum rotary speed detected by the speed detector **230** is about 78 rpm. According to an experiment, the maximum rotary speed detected by the speed detector **230** is about 76 rpm when the input voltage is 103 V and is about 79 rpm when the input voltage is 138 V.

In brief, when the position indicating members **231** are not omitted when the driving motor **80** is fully operate, the maximum rotary speed detected by the speed detector **230** is about 710 rpm. When one of the position indicating members **231** is omitted, the maximum rotary speed detected by the speed detector **230** is about 605 rpm.

Also, when the two position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, is about 490 rpm to 510 rpm. When the three position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, is about 350 rpm to 400 rpm.

Also, when the four position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, is about 235 rpm to 280 rpm. When the five position indicating members **231** are omitted, the maximum rotary speed of the rotating tub **30**, detected by the speed detector **230**, is about 78 rpm.

As described above, since the maximum rotary speed detected by the speed detector **230** varies depending on the number of the omitted position indicating members **231**, a plurality of reference speeds can be set and the number of the omitted position indicating members **231** can be determined.

As is apparent from the above description, a washing machine in accordance with one embodiment of the present disclosure includes a non-control type motor while minimizing a resonance phenomenon during a spin-drying operation.

Also, a washing machine in accordance with another embodiment of the present disclosure includes a clutch assembly while minimizing noise and vibration which occur while a driving motor operates.

Also, a washing machine in accordance with still another embodiment of the present disclosure includes a speed detector while detecting a failure of the speed detector.

Although the present disclosure has been described with an exemplary embodiment, various changes and modifications can be suggested to one skilled in the art. It is intended that the present disclosure encompass such changes and modifications as fall within the scope of the appended claims.

What is claimed is:

1. A washing machine comprising:
- an alternating current (AC) motor configured to generate torque;
- a clutch assembly configured to selectively transfer the torque to a rotating tub and a pulsator;
- a speed detector configured to detect a rotary speed of the clutch assembly; and
- a controller configured to repetitively perform operating and stopping the operation of the AC motor based on a predetermined target speed and the rotary speed of the clutch assembly during a spin-drying operation,
- wherein the controller is configured to gradually increase the torque of the AC motor while operating the AC motor during the spin-drying operation.

2. The washing machine of claim **1**, wherein the controller is configured to control a phase angle of AC power supplied from an external power supply and to supply the AC power controlled in phase angle to the AC motor while operating the AC motor.

3. The washing machine of claim **2**, wherein the controller is configured to supply at least a part of one cycle of an AC current supplied from the external power supply to the AC motor while operating the AC motor.

4. The washing machine of claim **3**, further comprising a driving switch unit configured to conduct or cut off the power supplied from the external power supply to the AC motor.

5. The washing machine of claim **4**, wherein the controller is configured to turn on the driving switch unit for a conduction time in one cycle of the AC power supplied from the external power supply while operating the AC motor.

6. The washing machine of claim **5**, wherein the controller is configured to gradually increase the conduction time while operating the AC motor.

7. The washing machine of claim **1**, wherein the controller is configured to stop the operating of the AC motor when the rotary speed is greater than a sum of the target speed and an allowable error while operating the AC motor.

8. The washing machine of claim **1**, wherein the controller is configured to begin the operating of the AC motor when the rotary speed is smaller than a difference between the target speed and an allowable error while stopping the operating of the AC motor.

9. The washing machine of claim **1**, wherein the target speed varies according to a time in which the spin-drying operation is performed.

10. The washing machine of claim **1**, wherein the speed detector comprises:
- a position indicating member configured to rotate together with the clutch assembly; and
- a speed sensor configured to detect the position indicating member and output an electric signal corresponding to whether the position indicating member is detected.

11. The washing machine of claim **10**, wherein the controller is configured to warn a user of a failure of the speed sensor when the rotary speed is "0" after the AC motor is operated.

12. The washing machine of claim **10**, wherein the controller is configured to warn a user of omission of the position indicating member when the rotary speed is smaller than a predetermined reference speed after the AC motor is fully operated.

13. A method of controlling a washing machine, comprising:
- operating an AC motor that generates torque during a spin-drying operation;
- detecting a rotary speed of a clutch assembly that transfers the torque to a rotating tub and a pulsator; and
- repetitively performing operating and stopping the operating of the AC motor based on a predetermined target speed and the rotary speed of the clutch assembly during the spin-drying operation,
- wherein the operating of the AC motor comprises gradually increasing the torque of the AC motor during the spin-drying operation.

14. The method of claim **13**, wherein the gradually increasing of the torque of the AC motor comprises:
- controlling a phase angle of AC power supplied from an external power supply; and
- supplying the AC power controlled in phase angle to the AC motor.

15. The method of claim **14**, wherein the supplying of the AC power controlled in phase angle to the AC motor comprises supplying at least a part of one cycle of an AC current supplied from the external power supply to the AC motor.

16. The method of claim **13**, wherein the repetitively performing the operating and stopping of the operating of the AC motor comprises stopping the operating of the AC motor when the rotary speed is greater than a sum of the target speed and an allowable error while operating the AC motor.

17. The method of claim **13**, wherein the repetitively performing the operating and stopping of the operating of the AC motor comprises beginning the operating of the AC motor when the rotary speed is smaller than a difference between the target speed and an allowable error while stopping the operating of the AC motor.

18. The method of claim **13**, wherein the target speed varies according to a time in which the spin-drying operation is performed.

19. The method of claim **13**, further comprising warning a user of a failure of a speed sensor which detects the rotary speed of the clutch assembly when the rotary speed is "0" after the AC motor is operated.

20. The method of claim **13**, further comprising warning a user of a failure of a speed sensor which detects the rotary speed of the clutch assembly when the rotary speed is smaller than a predetermined reference speed after the AC motor is fully operated.

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